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Irondequoit Basin Study

Monroe County, Rochester, NY

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This study focussed on the impact of phosphorus in stormwater runoff on bay eutrophication. Cost effective BMP's designed to minimize the impact and restore the bay to waters with enhanced recreation benefits. Use of wetlands in conjunction with a flow regulating device proved to be the most cost-effective control measure.

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The most cost-effective control measure evaluated was the use of the wetlands, located immediately upstream of the bay, as a sedimentation basin. This would be accomplished by constructing a flow regulating device at the "Narrows" within the wetlands. Other control measures may also be feasible but these measures will require site-specific investigations. These control measures should be implemented by the existing agencies currently involved in urban runoff management. Long term management of urban stormwater runoff, however, requires further definition.

This project was conducted by the Monroe County Departments of Engineering, Health, and Planning, the U.S. Geological Survey, the Center for Governmental Research, and O'Brien & Gere Engineers, Inc. This report was submitted in fulfillment of USEPA Grant No. P 002230-01-0 by the Monroe County Department of Engineering and their consultant, O'Brien & Gere Engineers, Inc., under the sponsorship of the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation.

ABSTRACT

As part of the Nationwide Urban Runoff Program (NURP), the United States Environmental Protection Agency (USEPA) assigned three grants to the New York State Department of Environmental Conservation (NYSDEC) to determine the significance of urban stormwater runoff on receiving water quality in New York State. One of these grants was specifically designed to address water quality issues in Irondequoit Bay in Monroe County. This study, the Irondequoit Bay NURP, was conducted to assess the impact of phosphorus contained in stormwater runoff on bay eutrophication. In addition, cost-effective mitigative control measures were evaluated that would minimize this impact and restore the bay to waters with enhanced recreational benefits.

The results of the flow monitoring, sampling, and analysis of streams tributary to Irondequoit Bay in conjunction with simplified runoff modeling indicated that about 46% of the annual phosphorus load reaching the bay via Irondequoit Creek is generated from the urban portion of the watershed, with the remainder resulting from the agricultural portion of the basin. The magnitude of phosphorus runoff loadings varied seasonally with the highest loadings associated with spring runoff .

Steady-state modeling of the bay indicated that water column phosphorus concentrations would decrease with reductions in external phosphorus loadings. This relationship was developed by assuming a zero net phosphorus release rate from the bottom sediments. Although some form of bay intervention may be necessary to accelerate the rate of improvement in bay water quality, the present external loading of 39 kg/day must be reduced to approximately 14 kg/day to maintain the bay in a trophic state cosistent with recreational usage.

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Nationwide Urban Runoff Program

Irondequoit Basin Study
Final Report

County of Monroe
Department of Engineering

Irondequoit Bay
Pure Waters District
Rochester, New York

April 1983

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NATIONWIDE URBAN RUNOFF PROGRAM
IRONDEQUOIT BASIN STUDY
FINAL REPORT

Submitted to the

MONROE COUNTY
DEPARTMENT OF ENGINEERING
MONROE COUNTY, NEW YORK

THIS STUDY WAS CONDUCTED
IN COOPERATION WITH

New York State Department of Environmental Conservation
Albany, New York

and

Water Planning Division
U.S. Environmental Protection Agency
Washington, D.C.

i.a

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about environmental quality. The complexity of our environment and the interplay among its components require concentrated and integrated approaches to pollution problems.

The possible deleterious water quality effects of nonpoint sources in general, and urban runoff in particular, were recognized by the Water Pollution Control Act Amendments of 1972. Because of uncertainties about the true significance of urban runoff as a contributor to receiving water quality problems, Congress made treatment of separate stormwater discharges ineligible for Federal funding when it enacted the Clean Water Act in 1977. To obtain information that would help resolve these uncertainties, the Agency established the Nationwide Urban Runoff Program in 1978. This five-year program is intended to answer questions such as:

- To what extent is urban runoff a contributor to water quality problems across the nation?
- What is the effectiveness of controls short of treatment in reducing water quality problems where they exist?
- Are best management practices for control of urban runoff cost effective in comparison to alternative options?

This study was conducted to answer not only these questions posed by the U.S. Environmental Protection Agency at the national NURP level, but to address the issue of the impact of urban stormwater runoff on the water quality of Irondequoit Bay, New York. The control measures identified herein are intended for application in the study area and do not necessarily represent control technologies that could be implemented on a nationwide basis.

Carl Myers, Acting Director
Water Planning Division
Washington, D.C.

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LIST OF ABBREVIATIONS AND SYMBOLS

A	area
AC	Allen Creek
ac	acre
ac-ft	acre-feet
APWA	American Public Works Association
BMP	Best Management Practice
BOD_5	biochemical oxygen demand (5 day)
CB	Central Basin
CGR	Center for Governmental Research
cm	centimeter
cm^2	square centimeter
COE	US Army Corps of Engineers
CR	Cranston
CSO	combined sewer overflow
DR3M	Distributed Rainfall Runoff Routing Model
DTD	Detailed Task Description
DOC	dissolved organic carbon
EMC	event mean concentration
EPAMAC	Environmental Protection Agency Macroscopic Planning Model
ER	East Rochester
ft	feet
G	geometric mean
ha	hectare
IBNURP	Irondequoit Bay Nationwide Urban Runoff Program
IBPWD	Irondequoit Bay Pure Waters District
IC	Irondequoit Creek
IGV	Irondogenesee Valley
in	inch
kg	kilogram
lb	pound
m	meter
m^3	cubic meter
mg/l	milligrams per liter
min	minute

LIST OF ABBREVIATIONS AND SYMBOLS (Continued)

MCDE	Monroe County Department of Engineering
MCHD	Monroe County Health Department
MCPD	Monroe County Planning Department
mi	mile
mi^2	square mile
mm	millimeter
NPS	nonpoint source pollution
NURP	Nationwide Urban Runoff Program
NYSDEC	New York State Department of Environmental Conservation
O&M	operations and maintenance
P	Phosphorus
PCP	Project Control Plan
PL	Public Law
Q	discharge
QA/QC	Quality Assurance/Quality Control
RC	runoff coefficient
S	storage volume
SCS	Soil Conservation Service (US Department of Agriculture)
SEQR	State Environmental Quality Review Act
SG	Southgate
SPCC	Spill Prevention, Control and Countermeasure Plan
SS	suspended solids
STP	sewage treatment plant
TAT	Technical Advisory Team
TC	Thomas Creek
TH	Thornell
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids (sediment)

LIST OF ABBREVIATIONS AND SYMBOLS (Continued)

µg/l	micrograms per liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WATSTORE	National Water Data Storage and Retrieval System
yr	year

SYMBOLS

>	greater than
<	less than
µ	micro

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SECTION 1
CONCLUSIONS

Based on the results of the Irondequoit Bay Nationwide Urban Runoff Program (IBNURP), the following conclusions are presented. A detailed discussion of each finding can be found in the section identified in parentheses after each conclusion.

1. Phosphorus is the most easily controlled nutrient contributing to the present eutrophic state of Irondequoit Bay. (Section 3)

2. An average summertime total phosphorus water column concentration of 20-30 µg/l is desirable to promote contact recreation and an improved fishery for Irondequoit Bay. (Section 4)

3. The largest quantities or loadings of phosphorus per unit of land area are associated with the urban portions of the Irondequoit Bay watershed. Based on 1980 and 1981 data from five sampling sites, the average phosphorus concentrations and loadings per storm event are as follows: (Section 6)

Monitoring Site	Predominant Land Type	Average Phosphorus Loading (kg/ha/event)	Average Phosphorus Concentration (mg/l/event)
East Rochester	Urban	0.01160	0.347
Southgate	Commercial	0.01264	0.172
Cranston	Suburban	0.00662	0.193
Thomas Creek	Rural	0.00399	0.105
Thornell	Rural	0.00686	0.097

4. For the five monitored sites identified in Item 3, the stormwater runoff phosphorus loadings exhibit seasonal variations. Loadings

constructing a flow regulating structure at a location known as the "Narrows" within the wetlands. (Section 8)

8. In addition to use of these wetlands, other structural control measures to reduce basinwide phosphorus loads are: (Section 8)

   a. The application of three in-stream impoundments located along Irondequoit and Allen Creeks ($51/kg P removed)
   b. Utilization of additional wetlands upstream of the bay ($61/kg P removed)

9. Other control measures, although effective in reducing phosphorus loads from stormwater runoff, were not evaluated on a similar cost-effective basis because they apply to small areas. The costs of these measures are variable depending on the characteristics of each area. These urban stormwater management measures include: (Section 8)

   a. The enactment of an erosion/runoff control ordinance based on performance standards
   b. Stormwater infiltration to the upper soil layers, especially in areas of new development
   c. The use of additional wetlands located throughout the overall Irondequoit Bay watershed

10. A reduction in the phosphorus loading from 14340 kg/yr (39.3 kg/day) to 7000 kg/yr (19.2 kg/day) can be achieved through the use of the wetlands at the mouth of Irondequoit Creek in conjunction with the construction of three in-stream impoundments along the creek. This reduction represents a 51% decrease (7340 kg/yr or 20.1 kg/day) in the present average annual phosphorus load to the bay from Irondequoit Creek. (Section 8)

associated with winter/spring runoff events are significantly greater than those associated with summer/fall events. Depending on the site, phosphorus loads vary from 0.0001 kg/ha/event to 0.0625 kg/ha/event. (Section 6)

5. Based on the application of a simplified runoff model, the annual phosphorus loadings for four subbasins comprising the Irondequoit Bay watershed tributary to Blossom Road are predicted to be as follows: (Section 7)

Subbasin	Phosphorus Loading (kg/yr)	Loading-Percent of Total	Unit Loading (kg/ha/yr)
Thornell	5090	36	0.44
Thomas Creek	1340	9	0.18
Allen Creek	5440	38	0.70
Central	2460	17	0.24
Totals	14340 (39 kg/day)	100	0.39

6. A steady-state water quality model calibrated with historical bay data indicates that decreases in water column phosphorus levels can be correlated with reductions in stormwater (external) phosphorus loadings. Because of uncertainties in the phosphorus release rates from the bottom sediments (internal loading), a precise relationship cannot be established. (Section 7)

7. The most cost-effective control measure to reduce the present basinwide stormwater runoff phosphorus load from Irondequoit Creek involves the use of the wetlands immediately upstream of the bay as a sedimentation basin. The annual cost for phosphorus removal by this method is $20/kg. Use of the wetlands as a sedimentation basin can be accomplished by

constructing a flow regulating structure at a location known as the "Narrows" within the wetlands. (Section 8)

8. In addition to use of these wetlands, other structural control measures to reduce basinwide phosphorus loads are: (Section 8)

   a. The application of three in-stream impoundments located along Irondequoit and Allen Creeks ($51/kg P removed)
   b. Utilization of additional wetlands upstream of the bay ($61/kg P removed)

9. Other control measures, although effective in reducing phosphorus loads from stormwater runoff, were not evaluated on a similar cost-effective basis because they apply to small areas. The costs of these measures are variable depending on the characteristics of each area. These urban stormwater management measures include: (Section 8)

   a. The enactment of an erosion/runoff control ordinance based on performance standards
   b. Stormwater infiltration to the upper soil layers, especially in areas of new development
   c. The use of additional wetlands located throughout the overall Irondequoit Bay watershed

10. A reduction in the phosphorus loading from 14340 kg/yr (39.3 kg/day) to 7000 kg/yr (19.2 kg/day) can be achieved through the use of the wetlands at the mouth of Irondequoit Creek in conjunction with the construction of three in-stream impoundments along the creek. This reduction represents a 51% decrease (7340 kg/yr or 20.1 kg/day) in the present average annual phosphorus load to the bay from Irondequoit Creek. (Section 8)

11. A reduction in the stormwater runoff phosphorus loading from the present 39 kg/day to a value no greater than 14 kg/day is required to improve the water quality of Irondequoit Bay to desirable levels. (See Conclusion 2) Because of uncertainties in the amount of phosphorus being released from the bottom sediments, the period of time necessary to achieve the desired water column phosphorus concentration through external loading reductions cannot be accurately determined. In any event, this reduction in stormwater loading must be achieved to maintain the bay in the desired trophic state. (Section 8)

12. Because of the reductions in external phosphorus loadings due to the elimination of point source pollutant discharges, bay phosphorus and chlorophyll concentrations have decreased since 1971. This decrease has led to a noticeable improvement in bay water quality. The water quality of Irondequoit Bay will likely improve in the future in approximate proportion to the reduction in external phosphorus loadings. (Section 8)

13. No single existing administrative entity meets all the criteria generally agreed upon to be necessary to manage nonpoint source pollution. Furthermore, no general agreement exists on the role of each currently involved governmental entity in the management of stormwater runoff or nonpoint source pollution. (Section 9)

14. Those governmental administrative entities currently involved in nonpoint source water quality management are capable of implementing the short-term control measures. (Section 9)

SECTION 2
RECOMMENDATIONS

Based on the results of the Irondequoit Basin Nationwide Urban Runoff Program, the following recommendations are presented:

1. Monroe County should prepare a comprehensive workplan for using the wetlands immediately upstream of Irondequoit Bay for stormwater runoff control. Such a plan should include an environmental assessment leading to the design and construction of a flow regulating structure at the "Narrows." Also included in the plan should be provisions for determining the effectiveness and long-term impacts of wetlands treatment.

2. Monroe County should formally establish definitive water quality objectives for phosphorus, chlorophyll, and water clarity for Irondequoit Bay. Recommended goals are average summer phosphorus and chlorophyll concentrations in the upper waters of the bay of 20-30 μg/l and 7-20 μg/l, respectively and a water clarity (Secchi disk) reading of at least 2 m.

3. Monroe County should investigate control measures applicable to specific high density urban areas, since these areas were found to contribute high pollutant stormwater loads to Irondequoit Bay.

4. An erosion/runoff control ordinance(s) based on performance standards, structured to meet local needs, and providing for a means of enforcement should be developed and adopted by county or local government(s).

5. Monroe County should continue to support and fund in-bay monitoring programs as well as flow recording and sampling of Irondequoit, Allen, and Thomas Creeks.

6. Drainage systems which maintain the natural infiltration of stormwater into the aerated (i.e. upper) soil layer should be considered for all new developments. Such drainage measures would minimize the rate and quantity of surface runoff and, therefore, should be encouraged by all municipalities. Site development feasibility studies should include consideration of subsurface conditions to aid in implementing this recommendation.

   Direct injection of stormwater into a usable groundwater aquifer, is not considered desirable, and therefore, is not recommended.

7. Monroe County should develop a comprehensive water quality management plan for the Irondequoit basin based on the results of this and other ongoing basin studies. Such a plan would:

   a. Resolve and integrate technical issues relating to established surface and groundwater quality goals and identify the most cost-effective mitigative control measures.
   b. Identify current agency roles relating to nonpoint source pollution.
   c. Develop the appropriate administrative arrangements to meet these objectives.
   d. Monroe County should continue its public information program as an integral part of the recommended water quality management plan.

SECTION 3
INTRODUCTION

GENERAL

This report addresses the impact of stormwater runoff on receiving water quality. As part of the Nationwide Urban Runoff Program, known as NURP, the United States Environmental Protection Agency (USEPA) awarded a grant to the New York State Department of Environmental Conservation (NYSDEC) to study the effects of urban stormwater runoff on the water quality of Irondequoit Bay, New York. The significance of pollution arising from nonpoint sources and the mitigative cost- effective control measures to combat such pollution are discussed herein.

Over the past ten years, improvements in receiving water quality have resulted primarily from improved treatment of wastewater and combined sewer overflow (CSO). Indeed, over the last sixteen years, millions of dollars have been spent by the USEPA for funding studies dealing with improving wastewater treatment and reducing CSOs. In addition, through the USEPA construction grants program, these two sources of pollution are presently being controlled on a nationwide basis by the construction and operation of over $50 billion worth of treatment facilities. Recent studies, however, have indicated that the potential pollution from urban stormwater runoff and other nonpoint sources may represent a significant portion of the total annual pollution load discharged to receiving waters (1-7). The magnitude of this problem may be greater when flooding and soil erosion impacts are considered.

Throughout the country, many of the larger metropolitan centers have embarked on massive receiving water restoration and cleanup projects as a result of both the Federal Water Pollution Control Act Amendments of 1972, Public Law (PL) 92.500, and the Clean Water Act Amendments of 1977 (PL 95.217). These programs, however, which address wastewater and CSO problems, do not address the potential urban stormwater runoff problem. In the late 1970's, Congress recognized the need to investigate this problem and acted by mandating that the USEPA must provide a report to Congress by January 1, 1983 identifying the needs and treatment costs associated with urban stormwater runoff (8). This report is intended to help answer the question and provide a basis on which to make a decision on whether the wastewater and CSO treatment facilities already built and under construction will restore the nation's receiving waters to a desirable level of quality or whether it will be necessary to treat urban stormwater runoff and other nonpoint pollution sources.

Under the Congressional mandate, the USEPA was authorized to spend $30 million to study 28 urban areas under a program known as the Nationwide Urban Runoff Program (NURP). Irondequoit Bay in Monroe County, New York was selected as one of the model study areas. Specifically, a grant of $1,131,200 was awarded to the NYSDEC, the implementing agency for USEPA water programs in New York State. NYSDEC, in turn, awarded a grant to the Irondequoit Bay Pure Waters District (IBPWD), the administrative group responsible for wastewater management within that portion of the Irondequoit Bay watershed in Monroe County. This study quantified the pollutant inputs to the bay via stormwater runoff and evaluated the costs, benefits, and implementability of various control measures.

The Irondequoit Bay NURP is one of twenty-eight such programs throughout the country which studied the impact of stormwater runoff on water quality. The information obtained throughout this program which included the determination of stormwater flows and water quality constituents provided valuable data to the national NURP program. Prior to NURP, only a limited data base had existed. Before the true impact of stormwater runoff on water quality could be determined, however, an extensive data base was required. The various NURP programs provided such a data base. The information gathered under the Irondequoit Bay NURP (IBNURP) also demonstrated the transferability of these data so that solutions and knowledge gained could be applied to other areas. In addition, information derived from other NURPs could be used to assess the severity of problems within the Irondequoit Bay watershed which were not specifically investigated under IBNURP, for example, such as the impact of priority pollutants on receiving water quality.

Irondequoit Bay (to be subsequently referred to as the bay) is a relatively small body of water on the southern shore of Lake Ontario and located immediately northeast of the City of Rochester, New York. It is about 6.7 km in length and 1 km in width with depths ranging from 3 to 23 m. Outflow to the lake is restricted to a small opening at the northern end while its principal tributary, Irondequoit Creek, enters at the southern end. The total drainage basin is about 395 km^2 and is comprised of urban, suburban, and agricultural lands. Hydraulic residence time within the bay is about 116 days (8).

The bay is presently in an advanced state of cultural eutrophication (8,9). A dense algal crop occupies its surface waters intermittently from early May to mid-October. Deep sediments, which have been characterized in the past as "black muck", underlie much of the bay. These and other problems, such as hypolimnetic oxygen depletion and high turbidity, all resulting from its current overproductive state, severely interfere with its potential use for bathing, boating, and fishing.

Although many elements are essential for plant and algal growth, in addition to micronutrients such as silicon, only nitrogen and phosphorus are considered the limiting nutrients that are controllable (10). In simple terms, a plant nutrient such as phosphorus, is said to be limiting if it is the least abundant among all other available parameters essential for plant growth. Irondequoit Bay does not appear to be nutrient saturated and is most likely phosphorus limited, since N:P ratios are considerably less than 30:1 (11). For this reason, phosphorus was the parameter selected for primary analysis in IBNURP. As such, control measures were evaluated on the basis of limiting the amount of phosphorus tributary to the bay through stormwater runoff.

Studies undertaken by the National Eutrophication Survey conducted in the early 1970's clearly indicated that there was a distinct correlation between land use and the concentrations of nutrients as measured in streams within the tributary watershed (12). These concentrations were found to be proportional to the percent of land in agricultural and urban land use. The intent of IBNURP was to determine the sources of pollutants in the watershed by land use and to develop control measures to limit the runoff induced pollutant loads. By intent, particular emphasis was given to the nutrient, phosphorus, which contributes to the present eutrophic state of the bay.

The general degradation of bay water quality has been a gradual process that has been accelerated in recent years because of rapid urban development (9). The public is aware of its present condition and has acted to reverse the trend towards lower water quality. This public opinion is reflected in their support of the $130 million that has been spent to date to divert sewage treatment plant effluent from entering the bay through the construction of a tunnel interceptor and for an additional $80 million to reduce CSOs entering the bay (13-15). These measures, in conjunction with the statewide legislative ban on phosphorus in detergents enacted in 1972, have significantly lowered the bay water column phosphorus concentrations. However, despite noticeable improvement, the problems associated with an excess phosphorus concentration remain (8,11).

Although these large expenditures have been and are being made to improve Irondequoit Bay, improvement in bay water quality has not been observed to the extent originally expected. Because of this, there remains a real concern about stormwater or nonpoint phosphorus loads which continue to enter the bay directly or via tributary streams. Such runoff likely limits or deters the intended restoration process. While much is known about the bay through extensive limnological studies which have been conducted to date, the impact of stormwater runoff on bay water quality remains uncertain (16-19). Thus, while the investment of federal, state, and local monies in pollution control helped reverse or slow the eutrophication process, attainment of stated water quality objectives within a reasonable period of time would remain uncertain, unless the impact of urban stormwater runoff is studied.

PROJECT ADMINISTRATION

The Monroe County Department of Engineering (MCDE) was designated as the principal administrative agency for IBNURP. Assistance was also provided by two other county agencies: the Health Department (MCHD) for sampling, analysis, and evaluations and the Planning Department for all program public participation elements. The MCDE retained the consulting firm of O'Brien & Gere Engineers, Inc. (OBG) to assist in all aspects of the program with primary emphasis on administration, formulation and evaluation of control measures, and preparation of reports. Important related studies of the bay were concurrently conducted by the Buffalo District of the U.S. Army Corps of Engineers (COE) and the University of Rochester under an agreement with the MCDE (20,21). The Center for Governmental Research (CGR) was also retained to assist in evaluating the institutional implementability of technically viable control measures.

As an integral part of IBNURP, the USEPA entered into an interagency agreement with the U.S. Geological Survey (USGS) which has responsibility for many water programs throughout the country. On a national basis, the USGS provided program support and guidance with particular emphasis on sampling and analysis, data interpretation, and water quality runoff modeling. For IBNURP, the USGS (Ithaca and Albany, NY) had responsibility for sampling and analysis, data interpretation, and mathematical modeling of stormwater runoff in terms of both quantity and quality. Those aspects of the USGS activities pertinent to this study are summarized in this report.

Two other related studies should also be mentioned at this point. Although stormwater runoff pollutant loads from the non-urban, agricultural portion of the Irondequoit Bay watershed were measured, control measures to reduce such loads were not investigated. To further quantify these loads and to study the options available to reduce the non-urban loads, the NYSDEC retained Dr. Douglas Haith of Cornell University(22).

IBNURP also did not address any remedial measures that could be applied to the bay itself. To investigate bay intervention techniques to improve water quality, the USEPA retained the Monroe County Health Department and the University of Rochester under provisions of the National Clean Lakes Program (23). Furthermore, it is the intention of the NYSDEC to evaluate all these separate projects and to recommend one water quality management master plan under a USEPA 208 program.

As indicated earlier, the purpose of IBNURP was to determine the pollutant loads associated with urban stormwater runoff within the Irondequoit Bay watershed and to determine whether a reduction in these pollutant loads would improve the water quality of the bay. The overall study awarded by the USEPA was supported by the USGS, NYSDEC, MCDE, MCHD, MCPD, OBG, and CGR. The large number of participants helped to insure that technically able personnel were responsible for each task and that many abatement alternatives were identified and investigated.

Because of the numerous organizations and individuals directly involved in IBNURP, the project required considerable coordination to insure no duplication of effort and the pursuit of a common goal. For these reasons, a detailed Project Control Plan (PCP) and a Detailed Task Delineation (DTD) were initially developed (24).

The program was effectively managed through meetings of a group of individuals from the various parties involved in the project. This group was known as the Technical Advisory Team (TAT) and met at 2 to 3 week intervals throughout the project. The groups who sent representatives to the meetings include:

Monroe County Water Quality Committee
Irondequoit Bay Subcommittee
Monroe County Department of Engineering
Monroe County Department of Wastewater Management
Monroe County Department of Planning
Monroe County Department of Health

United States Geological Survey, Ithaca, NY
New York State Department of Environmental Conservation,
Albany and Avon, NY
O'Brien & Gere Engineers, Inc.
Center for Governmental Research, Inc.
University of Rochester

PROJECT OBJECTIVES

The general problem associated with Irondequoit Bay was stated earlier. In fact, the Monroe County Pure Waters Agency once referred to it as one of the worst pollution problems in the county (25). The problem is clear, the causes are not. Projects completed or presently under construction dealing with limiting the volume of CSO discharged to the bay will undoubtedly have a positive impact on bay water quality. However, the amount of reversal in bay eutrophication that can be expected from these control measures had not been quantified. With the CSO and point source discharges significantly reduced, the significance of nonpoint pollution, or urban stormwater runoff, had to be addressed.

The program objectives, therefore, were threefold:

1) To establish the significance of urban stormwater runoff on the water quality of Irondequoit Bay.
2) To determine the effectiveness of control measures in reducing the impact of urban stormwater runoff on Irondequoit Bay.
3) To establish a data base of pollutant concentrations in stormwater runoff for use by the USEPA.

In satisfying the second objective, it was conceivable that the amount of phosphorus entering the bay via stormwater runoff could not be sufficiently limited by basin control measures such that eutrophication could be reversed to a level consistent with improved water quality within a reasonable period of time. The water column phosphorus concentration may be more dependent on internal loads (those resulting from phosphorus released from bottom sediments) than on the external loads.

The extent to which the bay is dependent on the internal loading is being addressed by the University of Rochester (21). Investigation of those measures which would have an immediate impact on bay quality (bay intervention) is concurrently being conducted by the University of Rochester and the Monroe County Department of Health under the National Clean Lakes Program (23).

Both national and local objectives of the project were identified. Nationally, the USEPA was interested in correlating runoff loading characteristics with land use. This objective was met through the sampling and analysis of runoff at five IBNURP monitoring sites as described in Section 5. Locally and nationally the interest was in identifying and evaluating measures to control pollutants found in urban stormwater runoff. This objective was realized through the sampling and analysis of major streams within the Irondequoit Bay watershed, assignment of pollutant loadings to the major subbasins within the watershed, and determination of the remedial or control measures to reduce these loadings.

PROJECT OVERVIEW

In planning the project, it was decided that simplified mathematical models would be used to evaluate the magnitude of the stormwater loadings and to assess the water quality impact of these loadings. A steady-state water quality model would then be used to translate reduced phosphorus loadings to bay water column phosphorus concentrations. Finally, a cost-effective analysis of selected alternative control measures would be conducted to determine the applicability of nonstructural Best Management Practices (BMPs) and selected structural measures.

An extensive monitoring program was established to determine the quantity and quality of stormwater runoff from watersheds having different land uses. A hydrologic-surface conveyance model was used to establish the relationship of rainfall to the quantity of water and phosphorus in Irondequoit Creek. Finally, a simple phosphorus budget model of the bay was developed and calibrated using field data that allowed for assessment of bay water quality given various combinations of external and internal loadings.

It is important to note that the conclusions stated in this report were based on using phosphorus as the critical water quality parameter. Although this constituent is responsible for bay eutrophication and its reduction in stormwater runoff will likely improve bay water quality, other constituents found in urban stormwater runoff may also contribute to water quality degradation. The control measures herein described will be effective in reducing the present phosphorus load to the bay with a corresponding improvement in water quality. Stormwater runoff loadings for other constituents are discussed in Appendix A.

In light of the water quality problems associated with Irondequoit Bay as discussed herein, the intent of IBNURP was to develop management strategies for improving bay water quality. The initial step in this process was the determination of the extent of the adverse water quality impacts on the bay currently caused by stormwater runoff. Once this was accomplished, selected control measures at various locations throughout the overall drainage basin to best mitigate these impacts were formulated. Impacts from future development, which is likely to occur over most of the basin except for the southernmost portion, were extrapolated from the analysis of the current situation and appropriate measures were identified to minimize these impacts.

PLAN OF STUDY

The grant, as approved by the USEPA, contained seven major work tasks which were identified and described in detail in a Plan of Study (26). A brief description of each major task is as follows:

Task 1 - Administration

To manage all aspects of the NURP project from grant receipt to submission of the final report.

Task 2 Runoff Loading Determinations

To determine the magnitude of specific pollutant loadings from typical urban areas, and to differentiate these loadings from those coming from undeveloped or rural lands.

Task 3 - Evaluation of Control Measures

To evaluate the cost-effectiveness of selected basin control measures on improving the water quality of Irondequoit Bay. No in-place control measures would be evaluated but rather a literature review of the effectiveness of known management control options was to be conducted.

Task 4 - Assessment of Water Quality Impacts

To determine the water quality response of Irondequoit Bay to the phosphorus loadings discharged from the urbanized areas under current levels of development with and without the control schemes postulated in Task 5. The sensitivity of bay water quality to future loadings with and without control schemes was to be tested.

Task 5 - Development of A Management Program

To formulate an overall basinwide management plan identifying the need for selected control measures that are both technically and institutionally implementable. In addition, an assessment of the authority and organizational structure capable of implementing such measures was to be made.

Task 6 - Involvement With The Public

To encourage individuals and organizations to state their social, economic, and environmental objectives and to identify problems they feel are real.

To encourage local public officials to also identify objectives and problems and to indicate the institutional impacts they believe are associated with various proposed control schemes.

To describe for individuals, organizations, and local public officials how the various control schemes support, interfere with, or are neutral to the objectives and problems they articulated during the course of the project.

Task 7 - Report Preparation

To report on loadings, control measures and water quality impacts in such a way that the USEPA can offer them as "transferable" to other urban areas.

The remaining sections of this report describe how the various tasks were accomplished and present the findings of the investigations. Section 4 presents background information the reader will find helpful in understanding the impact of phosphorus on receiving water quality. Section 5 provides a description of the study area. In Section 6, the sampling and analysis program conducted under IBNURP is summarized. A detailed description of the runoff and water quality mathematical modeling effort is given in Section 7. In Section 8, selected control measures to reduce the quantity of phosphorus in stormwater runoff are discussed with an emphasis on their cost-effectiveness. Included in Section 9 are the institutional considerations for implementing the recommended cost-effective control measures. Finally, all aspects of the IBNURP public participation program are discussed in Section 10.

SECTION 4
BACKGROUND

To assist the reader in understanding the impacts of stormwater runoff on Irondequoit Bay, a brief introduction to the relevant principles of limnology is presented in this section. For more detailed information, the interested reader is referred to any one of several textbooks on this subject (27,28).

As stated earlier, Irondequoit Bay is a highly eutrophic body of water because of the introduction of excessive quantities of plant nutrients, such as nitrogen and phosphorus. The process of eutrophication occurs naturally as these nutrients are washed off undeveloped watersheds by stormwater runoff, accumulate in the water column, and are eventually recycled from the bottom sediments. When human activities, most notably urban development, accelerate the rate at which the natural process occurs, the process is termed cultural eutrophication. Irondequoit Bay is an excellent example of a lake that has become over-enriched by extensive urban development that has occurred within the tributary watershed over the past 80 years.

Changes in water quality become unmistakable as a body of water becomes more eutrophic. Excessive algal growth occurs with increasing amounts of plant nutrients entering the lake from runoff. Seasonal algal blooms occur with the surface waters becoming green and murky. Unpleasant odors and tastes are also noticed as decomposition of aquatic plants results in oxygen depletion of the upper and lower waters. In response to a decreased oxygen supply, certain species of fish die.

Before discussing the current phosphorus loading to Irondequoit Bay, what effect on water quality it has, and what can be done to reverse this trend, a brief overview of the general characteristics of lakes is presented. It is because of special characteristics such as light transparency, the ability to retain heat, and the ability to dissolve many substances, that water is able to sustain plant and animal life in lakes.

Almost all plant life is dependent on sunlight for photosynthetic growth. The extent of plant growth is, therefore, related to light penetration, which is dependent on water clarity or transparency. In addition, dissolved substances make essential elements available to all living organisms.

Temperature layering or thermal stratification in lakes occurs because of temperature related changes in water density. The upper waters of a stratified lake, such as Irondequoit Bay, is known as the epilimnion. This circulating layer of water, resulting from daily temperature variations and wind induced currents, is separated from the dark, cooler, non-circulating bottom waters known as the hypolimnion. The boundary layer, or thermocline, is a region of rapid temperature change with depth.

Most North American lakes are thermally stratified except for very shallow ones in which wind induced currents prevent such stratification. Seasonal temperature variations result in four distinct periods of year in terms of thermal lake conditions. During the summer, sunlight warms the surface waters which remain above the cooler, denser bottom waters. In the fall, the air temperature becomes increasingly cooler, resulting in the eplimnion and hypolimnion water temperatures equalizing. As surface waters continue to cool and become more dense, they begin to mix with bottom waters. The movement of winds and currents results in a total overturn with reoxygenation of previously oxygen depleted bottom waters. A similar overturn occurs in the spring as the ice layer melts and water temperatures become uniform. As the surface waters are warmed to $4^{\circ}C$ (the temperature at which water reaches its maximum density), the heavier surface waters mix with the bottom waters and results in a complete overturn. Both the fall and spring overturns bring nutrients that have accumulated in the hypolimnion to the upper waters, where they stimulate algal growth.

Numerous ways have been devised for classifying lakes. The most common way, when discussing water quality, is by their plant productivity (29). There are many factors, however, that determine a lake's productivity. They include such parameters as the amount of nutrients entering the lake from the tributary watershed, the chemistry of the bottom sediments, and the depth and shape of the basin. Based on "trophic" or nutrient characteristics, lakes are commonly grouped into three basic categories: oligotrophic (lowest), mesotrophic, and eutrophic (highest) (29). These general categories have been further subdivided on the basis of the phosphorus concentration of the epilimnetic waters, chlorophyll a content (a measure of the amount of algal growth present), and Secchi disk (water clarity) readings. These relationships are presented in Table 1 (30).

TABLE 1. SINGLE PARAMETERS AS INDICATORS OF TROPHIC STATE

Trophic State	Chlorophyll a (μg/l)	Phosphorus (μg/l)	Secchi Disk (m)
Oligotrophic	<7	<10	>3.7
Mesotrophic	7-12	10-20	>2
Eutrophic	>12	>20	<2

For Irondequoit Bay, the present average phosphorus concentration in the epilimnion for the July-August period is approximately 100 μg/l (31). Secchi disk readings for the same period are generally 0.5 to 1.3 m and the chlorophyll a content is about 40 μg/l (32). Based on the criteria presented in Table 1, these values indicate that the bay is highly eutrophic. It has been further estimated that the phosphorus loading to the bay is about 40 kg/day or 2.19 gm P/m^2/yr (33). The question is how much of a reduction is necessary to allow the bay to become classified as mesotrophic.

First, it should be noted that the bay has shown some improvement in water quality since 1971 as a direct result of (1) the New York State phosphate detergent ban enacted in 1972 and (2) the elimination during 1978 and 1979 of fourteen sewage treatment plants which had previously discharged to Irondequoit Creek and its tributaries. This decreased external loading over the past 10 years has resulted in improved bay water quality as evidenced by the reduction in the phosphorus concentration of the epilimnion and a corresponding decrease in chlorophyll a content, as shown in Figures 1 and 2, respectively (33). As illustrated, the trend has been a decrease from over 500 mg P/l to about 100 mg P/l. It is expected that further reductions will be realized with additional reductions in external phosphorus loadings. The straight line in Figure 1 is shown as dashed for the years prior to 1975 because in those earlier years, the bay did not overturn.

As discussed in more detail in Section 8, management objectives had been initially proposed to establish the significance of urban stormwater runoff as a contributor to bay eutrophication and to put it into perspective with nonpoint sources. These objectives are summarized in Table 2.

TABLE 2. PHOSPHORUS CONTROL STRATEGY CRITERIA

	Management Objectives	External P Loading to Bay ($gm/m^2/yr$)	Percent P Reduction	Residual P Sources
1.	No Diversions	9.68 (177)	0.0	20 from NPS
2.	Divert only STPs	2.52 (46)	75.8	78% from NPS
3.	Divert all STPs and CSOs	1.73 (32)	81.2	100% from NPS
4.	Achieve Eutrophic-Mesotrophic Threshold	0.67 (12)	93.0	61 Reduction of NPS
5.	Achieve Mesotrophic-Oligotrophic Threshold	0.34 (6)	96.0	80% Reduction of NPS

Note: NPS = nonpoint source (pollution)
STP = sewage treatment plant
CSO = combined sewer overflow
P = phosphorus
( ) = represents loading in kg/day

FIGURE 1

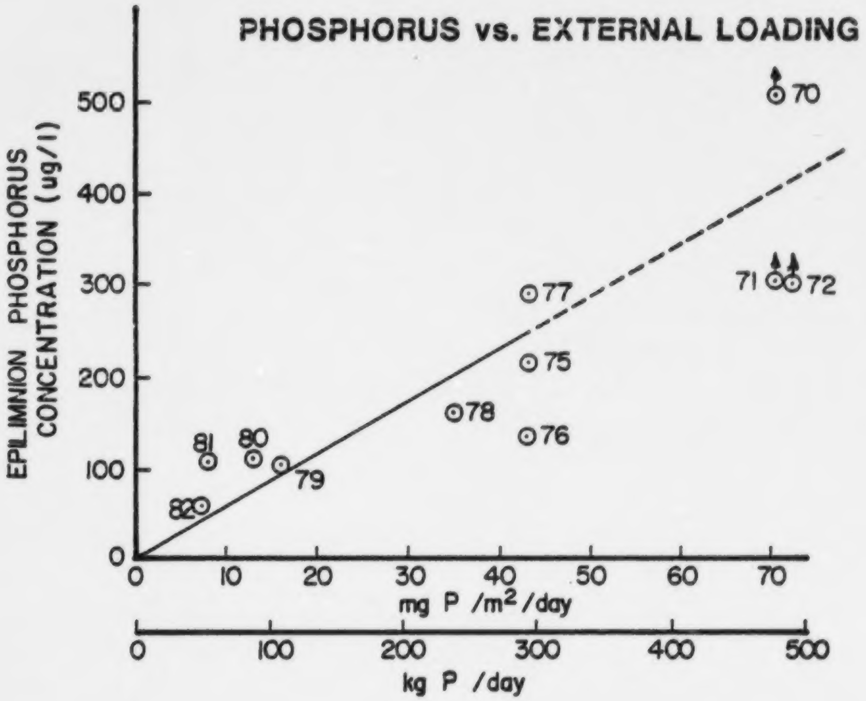
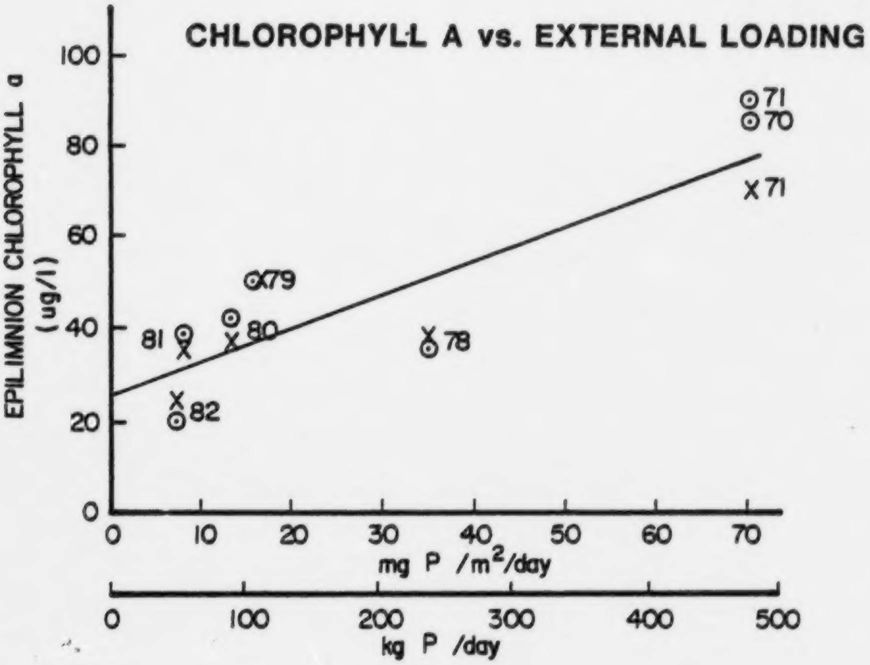

PHOSPHORUS vs. EXTERNAL LOADING

FIGURE 2


CHLOROPHYLL A vs. EXTERNAL LOADING

This table was prepared from data supplied by the University of Rochester, a NYSDEC bay survey of September 1976, and Vollenweider's curves on "dangerous" and "permissible" phosphorus loadings to the bay (8). Objectives 1 and 2 have already been achieved with a corresponding external phosphorus load reduction to approximately 2.5 gm P/m^2/yr. Unless otherwise noted, phosphorus in this report refers to total phosphorus or, in other words, the sum of the particulate and dissolved species. Objective 3 should be met during the mid-1980's, after completion of the ongoing USEPA construction grant programs to reduce CSOs. Although objectives 4 and 5 may not be entirely achievable, it is apparent that significant additional loading reductions must be realized to improve the water quality of Irondequoit Bay. Subsequent sections of this report discuss the effectiveness of selected management control measures in reducing the external phosphorus loading to a level identified as meso-eutrophic.

It should be noted that expected future improvement in Irondequoit Bay water quality may not be immediately realized upon additional external phosphorus load reductions for two reasons: 1) as one system variable is changed, such as external phosphorus loads, new equilibrium states are reached as the bay "adjusts" to these changes and this transition period requires time to complete, and 2) the amount of phosphorus released from the bottom sediments (the internal loading) may represent a significant proportion of the bay's overall phosphorus budget. Although reduced external loadings will likely lead to decreased internal loadings, the present quantity of phosphorus being released by the bottom material may be enough to maintain the bay in an eutrophic state for a long period of time, even if external loadings are substantially reduced.

For these reasons, the water quality modeling effort discussed in Section 7 included the assumption of negligible internal loading. Thus, the response of the bay to reduced external phosphorus loadings could be assessed and quantified independently from the internal loading, which is both difficult to quantify and presently unknown. This approach assumes that measures or techniques do exist for bay intervention in which the internal load can be essentially eliminated within a short period of time.

Should this be done, then the allowable external phosphorus load is that for which the bay can be maintained in an improved trophic state.

SECTION 5
DESCRIPTION OF STUDY AREA

The intent of this section is to present an overview of some of the more important factors concerning the overall drainage basin. Much of the information presented in this section was extracted from a source reference compiled by Bloomfield (32).

GENERAL

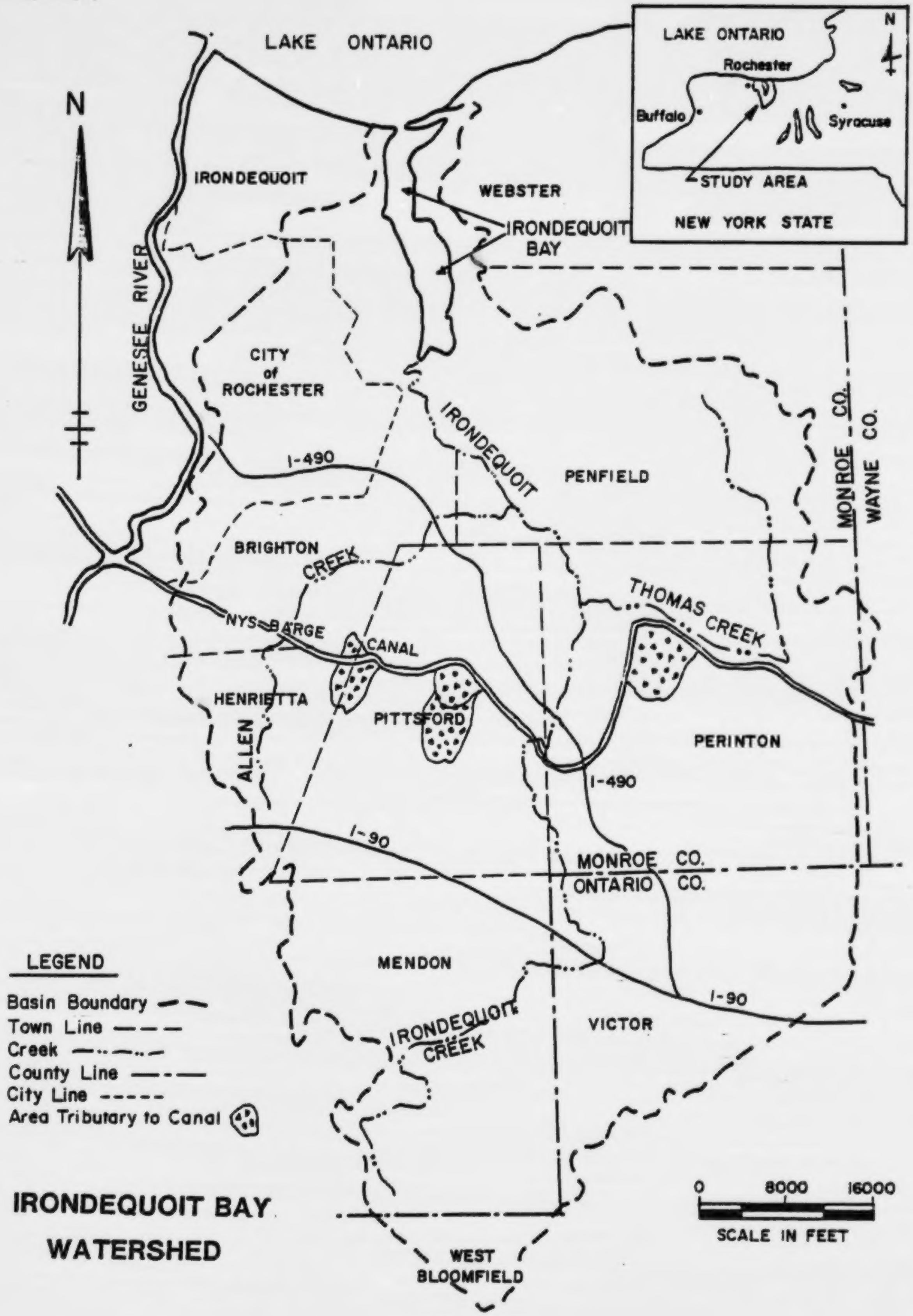
Drainage Basin

Figure 3 shows the boundary of the Irondequoit Bay drainage basin as established by the U.S. Geological Survey (USGS) through visual inspection of their topographic maps. Numerous field investigations were conducted by various IBNURP participants to verify the reasonableness of the boundary.

Based on USGS mapping procedures, the area of the overall Irondequoit Bay watershed is approximately 395 km^2. Elevations in the basin range from 75 m (mean level of Lake Ontario) to about 335 m in the southernmost portion of the basin in the Town of Victor. The watershed includes eastern portions of the City of Rochester and the Towns of Irondequoit, Webster, Brighton, Henrietta, Penfield, Pittsford, Perinton, and Mendon in Monroe County; portions of the Towns of Victor and West Bloomfield in Ontario County; and a small area in the Town of Macedon in Wayne County.

Three relatively small areas within the overall basin boundary do not drain into the creek system leading to the bay, but rather drain directly into the Barge Canal. These areas are shown in Figure 3. The fact that these areas are not tributary to the bay does not affect any of the runoff loading and modeling results discussed in later sections.

FIGURE 3


LAKE ONTARIO
N
IRONDEQUOIT
WEBSTER
IRONDEQUOIT BAY
GENESEE RIVER
CITY of ROCHESTER
IRONDEQUOIT
PENFIELD
I-490
BRIGHTON
CREEK
THOMAS CREEK
NYS BARGE CANAL
HENRIETTA
PITTSFORD
PERINTON
ALLEN
I-490
I-90
MONROE CO.
WAYNE CO.
MONROE CO.
ONTARIO CO.
MENDON
VICTOR
I-90
IRONDEQUOIT CREEK
WEST BLOOMFIELD
LAKE ONTARIO
Rochester
Buffalo
Syracuse
STUDY AREA
NEW YORK STATE
N
LEGEND
Basin Boundary
Town Line
Creek
County Line
City Line
Area Tributary to Canal
0
8000
16000
SCALE IN FEET

IRONDEQUOIT BAY WATERSHED

Barge Canal

The NYS Barge Canal traverses the IB drainage basin and modifies its surface hydrology by periodically augmenting flow in Irondequoit Creek. Water from the canal can be discharged to Allen Creek through several siphons. The canal is usually filled in April and drained in November partially into the Irondequoit Creek drainage system. Prior to the sewage treatment plant (STP) diversions completed in 1979, three STPs discharged their effluent into the canal. At that time, the nutrient loading to the canal from these STPs had a significant impact on the bay. Since these effluents no longer enter the canal (as was the case for the period covered by this project), the effect on the bay from canal water, relative to drainage from the remaining portions of the watershed, is small, and, therefore, was neglected.

Geology and Soils

Monroe County is covered by thick glacial drift deposits overlain on sedimentary strata. These strata are generally composed of shales, sandstones, and limestones. A bedrock map of the study area is available from the New York State Museum and Science Service (34). The geology of the basin has been summarized by Tressler and Bubeck (16, 35). It is important to note that most of the watershed is covered by thick, very permeable glacial till deposits.

According to the Monroe County Soil Survey (1973) four major soil groups and eight soil associations occur within the Irondequoit Bay basin (36). Soils throughout the basin generally range from well drained to poorly drained soils. The applicability of several control measures discussed in Section 7 depend on the inherent permeability of these soil systems. The Soil Survey of Monroe County has also characterized the sloped areas within the County as follows: 4.2% of the area with slopes of 6-15%, 1.2% of the area by slopes of 15-25%, and only 2.4% of the total area by slopes exceeding 25% (32).

A wide buried valley exists throughout a portion of the Irondequoit Bay watershed that is known as the Irondogenesee Valley (IGV). During the last glacial period (Tertiary era), a flow of considerable magnitude, certainly much greater than the current flow of the Genesee River, followed the present course of Irondequoit Creek. This river cut a large valley through the higher ground south of the Lake Ontario shoreline. This valley was widened and deepened by subsequent glacial action. The magnitude and extent of the IGV can be readily observed along portions of Irondequoit Creek. Since the material that subsequently was deposited in this valley was of glacial origin, the resulting soils consist of highly permeable sands and gravels. For more information dealing wth the IGV, the reader is referred to a detailed discussion by Fairchild (37).

Population

The estimated population of the Irondequoit Bay drainage basin is given in Table 3. These numbers were established using the 1980 U.S. Census data in conjunction with information provided by the Center for Governmental Research (38). The historical pattern of growth is a general movement of people from the City of Rochester and from outside of Monroe County to the towns generally south and east of the city and north of the canal. This pattern is likely to continue to the point whereby residential areas will develop in the agricultural lands within the basin south of the canal.

TABLE 3. ESTIMATED POPULATION OF DRAINAGE BASIN

Political Division	Population in 1980	Percent area in basin	Estimated Population	Population Density (people/ha)
City of Rochester	241741	31	74940	26.3
Town of Brighton	35776	84	30050	9.2
Town of Henrietta	36134	21	7590	4.0
Town of Irondequoit	57648	67	38620	14.0
Town of Mendon	5434	67	3640	0.5
Town of Penfield	27201	65	17680	2.8
Town of Perinton	41802	91	38040	4.7
Town of Pittsford	26743	99	26480	4.4
Town of Victor	5784	66	3820	0.6
Town of Webster	28925	6	1740	3.2
Total Population of Basin			242600	6.1

Land Use

The urban areas within the basin include the City of Rochester, the portions of the Towns of Irondequoit, Webster, Henrietta, Penfield, and Brighton lying in the basin, and the northern portions of the Towns of Pittsford and Perinton. To the south, especially south of Interstate 90, agricultural lands predominate. For greater detail, the reader is referred to land use maps prepared by the Monroe County Department of Planning (39).

Precipitation

The climate of the study area is moderate with generally warm, humid summers and cold, dry winters. Average daytime temperatures range from 27.8°C in July to 0.6°C in January. Average nighttime lows are from 16.1°C in July to -8.3°C in February. Winds are predominately from the southwest.

Average annual precipitation is about 80 cm with the maximum occurring in March and the minimum in December. Average annual snowfall is approximately 216 cm.

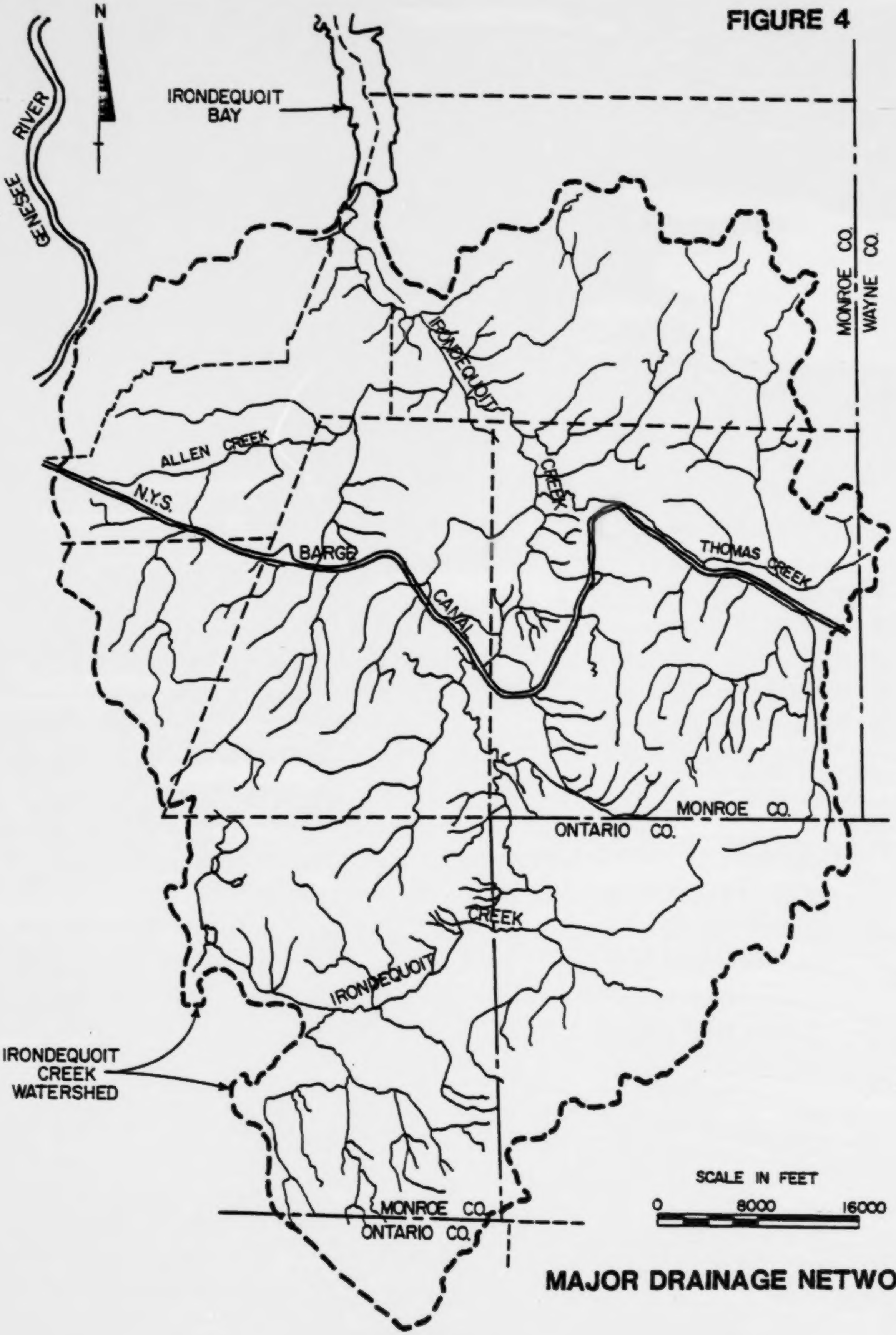
High intensity, short duration events are usually associated with thunderstorms occurring during the summer months; whereas, lower intensity, longer duration events are usually associated with cyclonic activity occurring during the spring and fall months (40). Weather patterns throughout the watershed are somewhat altered from the general inland areas because of the proximity to Lake Ontario.

Drainage

Other than areas immediately adjacent to the bay and the three areas along the canal (See Figure 3), the Irondequoit Bay watershed is drained by Irondequoit Creek and its tributaries. The creek begins in the southern portion of the Town of Mendon in Monroe County and flows generally in a northerly direction, discharging into the southern end of the bay at Empire Boulevard. A description of various segments of the creek from its headwaters to the bay is given by Bloomfield (32). Figure 4 shows the major drainage network within the basin.

Except for piped drainage systems within the villages and most residential developments throughout the basin, all stormwater runoff is conveyed by natural open-channels. Although there are no combined sewers within the Irondequoit Bay watershed, CSO is presently discharged into the bay from the City of Rochester's combined sewer system. As stated previously, these CSOs will be eliminated upon completion of the ongoing construction grant programs.

FIGURE 4


N
IRONDEQUOIT BAY
GENESEE RIVER
MONROE CO.
WAYNE CO.
IRONDEQUOIT CREEK
ALLEN CREEK
N.Y.S. BARGE CANAL
THOMAS CREEK
MONROE CO.
ONTARIO CO.
IRONDEQUOIT CREEK
IRONDEQUOIT CREEK WATERSHED
MONROE CO.
ONTARIO CO.
SCALE IN FEET
0
8000
16000

MAJOR DRAINAGE NETWORK

Sanitary and industrial wastes are conveyed by sewers leading to the Irondequoit Creek Interceptor which eventually discharges into the Cross-Irondequoit Tunnel. This system has eliminated the effluent discharge of all STPs previously discharging to the Irondequoit Creek network and thus to the bay, as discussed in Section 4. Because of this fact, and aside from the internal recycling of phosphorus within the bay itself, essentially all of phosphorus load from the watershed results directly from stormwater runoff. The proportion of phosphorus loadings resulting from various sources was shown in Section 4.

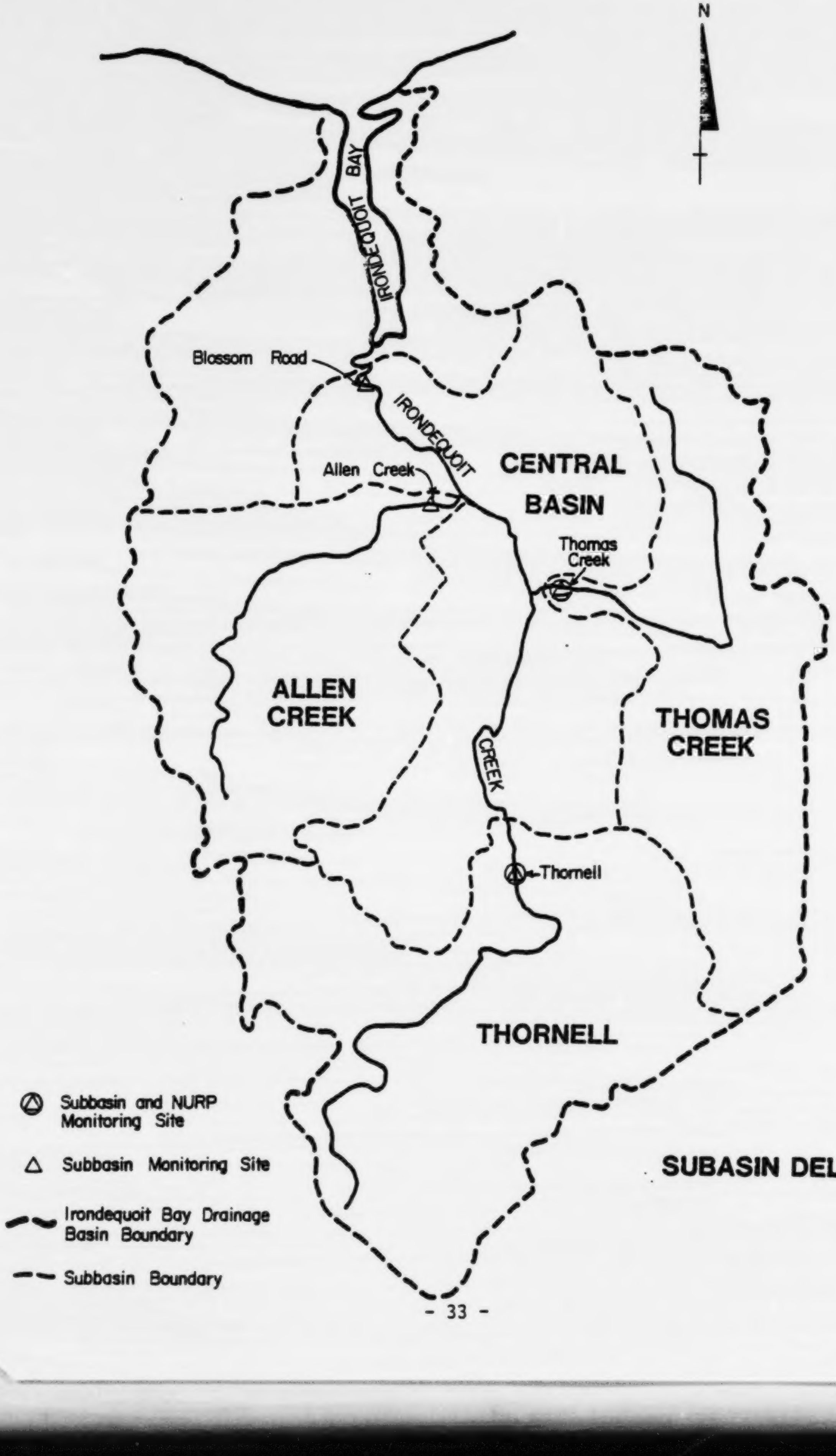
Current Practices

The effectiveness of various control measures depends, to a large degree, on the current practices existing within the watershed. That is, in order to determine those areas in which improvements to existing practices could be made, it was necessary to first compile an inventory of all existing practices. To compile this list, all town, village, county, state, and federal agencies which have jurisdiction within any part of the Irondequoit Bay watershed were consulted. The effect of current practices on the implementation of control measures is discussed in greater detail in subsequent sections.

SUBBASIN DELINEATION

To evaluate the applicability of various control measures to reduce phosphorus contained in stormwater runoff, the overall Irondequoit Bay watershed was divided into four major subbasins to better define the major sources of phosphorus within the basin. Figure 5 shows these four subbasins. They are further described as follows:

FIGURE 5


N
IRONDEQUOIT BAY
Blossom Road
IRONDEQUOIT
Allen Creek
CENTRAL BASIN
Thomas Creek
ALLEN CREEK
CREEK
THOMAS CREEK
Thornell
THORNELL
Subbasin and NURP Monitoring Site
Subbasin Monitoring Site
Irondequoit Bay Drainage Basin Boundary
Subbasin Boundary

SUBASIN DELINEATION

1. Thornell (TH) - This subbasin represents most of the non-urban, agricultural portion of the IB watershed. Discharge and pollutant loads from this subbasin were determined using data provided by the Thornell IBNURP monitoring site on Irondequoit Creek at Thornell Road. The IBNURP monitoring sites are described in greater detail following the subbasin descriptions. Basin information other than quantifying the size and computing the runoff coefficient by storm was not determined because the Thornell subbasin is not part of the urban drainage basin. However, the pollutant load generated from this area entered the urban portion of the IB watershed and, therefore, had to be determined, since the Thornell subbasin represents almost one-third of the overall IB watershed.

2. Thomas Creek (TC) - This subbasin represents the eastern portion of the IB watershed drained by Thomas Creek and its tributaries. The subbasin consists of varying land uses - that portion lying north of the canal being mostly suburban and that portion south of the canal being largely agricultural. Discharge and pollutant loads from this subbasin were determined using data provided by the Thomas Creek IBNURP monitoring site.

3. Allen Creek (AC) - This subbasin represents a highly urbanized portion of the IB drainage basin, although a small amount of agricultural lands are present. Although not monitored as part of the IBNURP monitoring program, discharge measurements have been recorded by a permanent gauging station maintained since 1959 by the USGS and located on Allen Creek just upstream from Irondequoit Creek. Sampling was conducted by the Monroe County Health Department (MCHD) throughout this study, so that pollutant loadings could be determined.

4. Central Basin (CB) - This subbasin represents that portion of the IB watershed tributary to the Blossom Road gauging station but excluding inflow from the Thornell, Thomas Creek, and

Allen Creek subbasins. The southern portion of this subbasin is highly urbanized similar to the Allen Creek subbasin. The northern portion is largely undeveloped. It is important to note that the stormwater runoff and pollutant loads from this subbasin were not measured directly but were calculated as the difference between the Blossom Road values and the sum of the Thornell, Thomas Creek, and Allen Creek values.

To better understand these subbasins, Table 4 presents some of the more important basin characteristics.

TABLE 4. SUBBASIN CHARACTERISTICS

Subbasin	Area (ha)	Percent of Total Area[1] (%)	Runoff Coefficient[2]	Population[3] Density (people/ha)	Predominant Land Type
Thornell	11508	31	0.10	0.59	Rural
Thomas Creek	7387	20	0.20	2.08	Rural - Some Suburban
Allen Creek	7802	21	0.32	8.23	Suburban
Central	10368	28	0.28	7.59	Suburban - Some rural

[1] Based on the Irondequoit Bay watershed tributary to Blossom Road.

[2] Estimated from percent land use and typical runoff coefficients for various land uses (10).

[3] Determined from estimated subbasin area within given town and population data given in Table 3.

As can be seen from Table 4, Thornell represents the most rural, non-urban portion of the Irondequoit Bay watershed with an estimated runoff coefficient of only 0.10 and a population density of only 0.59 people/ha. Although the Thomas Creek subbasin is mostly rural, there is suburban development towards the western portion of the basin. The suburban portion of this subbasin generally accounts for the increase in the runoff coefficient over that for the Thornell subbasin. A corresponding increase in the subbasin population density is also observed. Both the Allen Creek and the Central subbasins represent the highly urbanized portion of the overall bay watershed as evidenced by a significantly higher runoff coefficient and population density. As will be illustrated later in Section 6, the highest pollutant loadings per unit area for selected 1981 monitored storm events were associated with the two suburban subbasins.

Based on a total bay drainage basin of 395 km^2, the portion of the watershed not represented by the four subbasins is approximately 25 km^2 or about 6% of the total. Thus, the major portion of stormwater runoff entering the bay results from its main tributary, Irondequoit Creek, as measured at Blossom Road. Since the area downstream of Blossom Road represents a small portion of the total watershed, it is intuitively likely that the pollutant loadings from this area would also be small in comparison to the total load entering the bay via the creek. For completeness, a discussion of stormwater runoff loadings from areas downstream of Blossom Road is presented in Section 7.

NURP SAMPLING SITES

To comply with the USEPA need for pollutant loadings associated with different land uses, five monitoring sites were established. These were selected by the USGS and others and are further described in Appendix A. Each site has an associated tributary drainage area that is relatively small in relation to the entire Irondequoit Bay basin. Because of this, boundaries for each area were accurately established and the runoff measurements and sampling easily conducted. Monitoring of small, well defined watersheds allowed for reliable and accurate pollutant runoff determinations.

The five land use monitoring sites are identified in Table 5 and are shown in Figure 6. The extent of the drainage area tributary to each land use monitoring site is also shown in Figure 6.

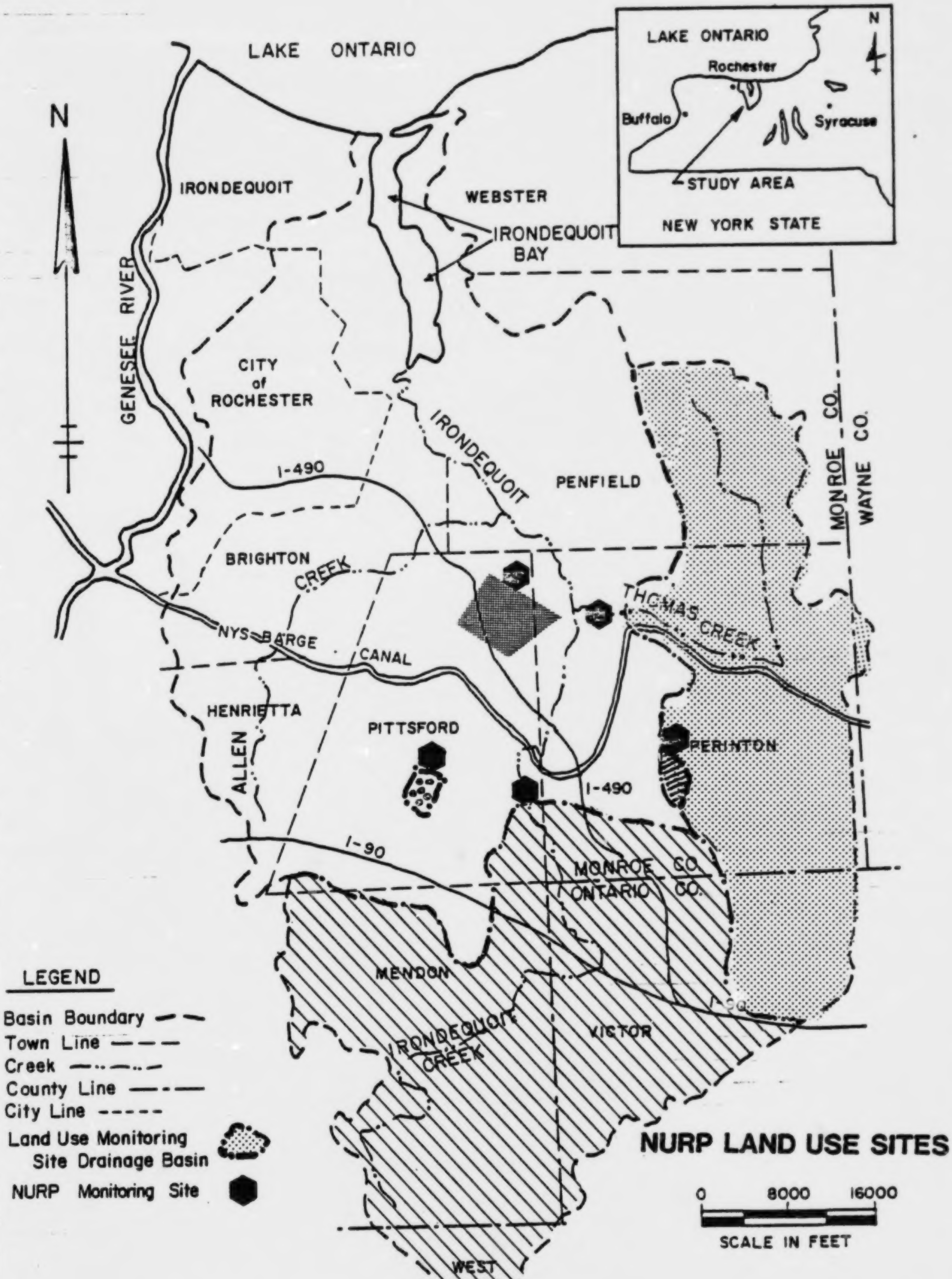
TABLE 5. NURP LAND USE MONITORING SITES

Monitoring Location	Wastercourse to Which Basin is Tributary	Drainage Area km^2	Land Use
Thornell Road	Irondequoit Creek	115	Rural/Agricultural
Thomas Creek	Thomas Creek	73.8	Mixed
Cranston Road	Barge Canal	0.67	Middle density residential
Southgate Road	White Brook (tributary of Thomas Creek)	0.73	Commercial
East Rochester	(Storm sewer discharging to Irondequoit Creek)	1.55	High density residential/commercial

To satisfy the national NURP objectives, information on the physical characteristics of each monitored land use watershed was required. Such specific site data as percent imperviousness, soil conditions, population, percent of area that is sewered, length and condition of roads, and other parameters were needed to relate the loadings from one area to other areas around the country on the basis of similar basin charactertistics. For IBNURP, such basin data were determined and summarized in a standard USEPA NURP form known as the fixed-site data report.

Flow monitoring at four of the five land use sites was accomplished by converting a stage or depth of flow, the primary measurement, into

FIGURE 6


LAKE ONTARIO
N
IRONDEQUOIT
WEBSTER
IRONDEQUOIT BAY
GENESEE RIVER
CITY of ROCHESTER
IRONDEQUOIT
PENFIELD
I-490
BRIGHTON
CREEK
THOMAS CREEK
NYS BARGE CANAL
MONROE CO.
WAYNE CO.
HENRIETTA
ALLEN
PITTSFORD
PERINTON
I-490
I-90
MONROE CO.
ONTARIO CO.
MENDON
IRONDEQUOIT CREEK
VICTOR
I-90
WEST BLOOMFIELD
LAKE ONTARIO
N
Rochester
Buffalo
Syracuse
STUDY AREA
NEW YORK STATE
LEGEND
Basin Boundary
Town Line
Creek
County Line
City Line
Land Use Monitoring Site Drainage Basin
NURP Monitoring Site
0
8000
16000
SCALE IN FEET

NURP LAND USE SITES

a discharge or rate of flow value according to a calibrated and verified stage/discharge relationship. At the East Rochester site, flow was computed directly by a Marsh-McBirney electronic head and velocity meter. Depth was computed by a pressure sensor, whereas, velocity was determined by an electromagnetic sensor. To insure that accurate hydrographs were calculated from the stage recorders, field calibration and verification methods were applied to maintain the best stage/discharge relationship. All sampling was accomplished by the use of flow proportional samplers manufactured by Manning Corporation. Each of the five monitoring sites also measured precipitation by a recording raingauge. A summary of the type, method, and recording procedure for runoff flow monitoring and sampling is presented in Table 6.

TABLE 6. FLOW MONITORING AND SAMPLING METHODS

Monitoring Location	Flow Monitoring	Sampling	Rainfall
Thornell Road	Mercury manometer bubbler gage-records in graphical and 15-min digital form.	Manning Sampler stage-activated or flow-proportional samples.	Volumetric 5 min digital output
Thomas Creek	Stilling well-float method-records in graphical and 15 min digital form	Same as Thornell Road	
Cranston Road	Same as Thornell Road - except records in 5 min digital form	Same as Thornell Road	
Southgate	Same as Cranston Road		
East Rochester	Marsh-McBirney flowmeter	Same as Thornell Road	

SECTION 6
SAMPLING AND ANALYSIS

GENERAL

It is the intent of this section to present a summary of the IBNURP sampling and analysis program with particular emphasis on determination of phosphorus loads from the five NURP monitoring sites and the five subbasins. Additional information is provided in Appendix A.

A major component of all NURP programs was the acquisition of a substantial data base consisting of rainfall, runoff, water quality constituents, and physical land characteristics of small watersheds. The principal USEPA objective was to summarize the characteristics of urban stormwater runoff by reviewing the data sets of the individual NURPs and to examine any similarities or differences in a way which would make reliable quantitative statements concerning the "transferability" of such data.

For IBNURP, the data collection effort had two objectives. One was to satisfy the needs of national NURP. The second, was to provide sufficient data to properly assess the impact of stormwater runoff on Irondequoit Bay water quality and to evaluate control measures. Relative to the USEPA needs, five watersheds were extensively monitored from July 1980 through August 1981. Selection of these five sites was made by the USGS and the MCHD and was based primarily on land use. To satisfy the local objectives, several additional points within the Irondequoit Bay watershed were also monitored. These points were selected so that the runoff loadings from four major subbasins could be calculated. These sites and subbasins were identified in Section 5.

As previously identified, the five monitored NURP basins were:

1. Thornell Road
2. Thomas Creek

3. Cranston Road
4. Southgate Road
5. East Rochester

A substantial amount of data dealing with the physical characteristics of each watershed was collected during IBNURP for utilization by the USEPA. These data were obtained by a review of available town maps, USGS topographic maps, discussions with town and county officials, and actual field inspections. Such information was transmitted to the USEPA through forms known as fixed-site data reports. This was referred to in Section 5.

Although not used directly, Landsat data (earth surface information provided through satellite photography) were provided for use in IBNURP by the USGS (Wisconsin). The original intent of these data was to provide general land use information for the watershed so that runoff coefficients could be estimated. These data were also to provide an estimate of the percent imperviousness of a watershed based on its land use. Such information was needed for the runoff model being developed by the USGS.

Comparison of field determined percent imperviousness to Landsat values for several basins indicated that the use of Landsat data without knowledge of the area or without field checking may yield misleading data. From the investigations conducted to date, it appears that Landsat determined land use data is adequate for large areas for water resource planning purposes. When modeling a small basin to establish the relationship between rainfall, runoff, and land use, however, field documentation is required. It should be noted, however, that Landsat data have been successfully used for runoff synthesis in a Soil Conservation Service runoff model (41).

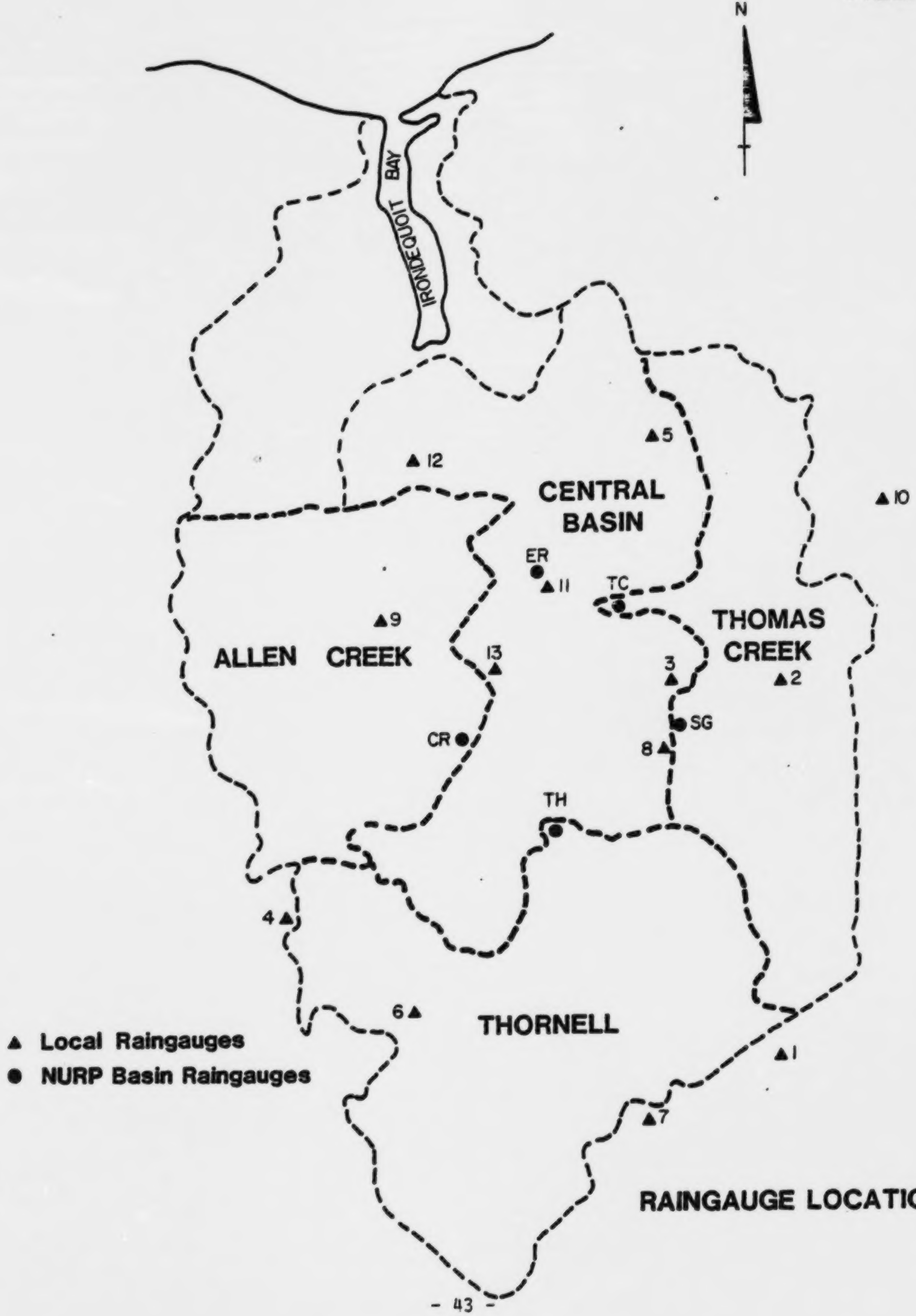
RAINFALL

Rainfall data were collected at the five monitoring locations as well as at thirteen other locations throughout the IB drainage basin. Table 6 in Section 5 summarized the type of rainfall data collected at the five monitored watersheds. The five minute rainfall information provided for an accurate representation of the actual rainfall hyetograph (plot of rainfall intensity vs time) for each storm event. To supplement the needs of the rainfall data collection effort, thirteen non-recording raingauges were installed throughout the overall basin. These raingauges were generally located in people's yards and were read once per day. Although only a total depth of rainfall was recorded, the information obtained from the local raingauge network provided an estimate of the uniformity of rainfall throughout the basin. Figure 7 shows the locations of both the local and IBNURP raingauges.

For the three smaller monitored basins - Cranston, Southgate, and East Rochester, the assumption of uniform rainfall as measured by one raingauge was reasonable. However, for the Thornell and Thomas Creek basins, the tributary drainage area for each was sufficiently large such that the assumption of uniform rainfall over those basins, as measured by one raingauge, was not valid. For these two basins, total rainfall was estimated from a review of the local raingauge information. Use of the local raingauge network also established the rainfall depths for the monitored storm events for the non-NURP monitored subbasins, such as the Allen Creek and Central subbasins.

In addition to the rainfall data recorded at the land use-event sites and from the local raingauge network, atmospheric deposition of pollutants was also measured by three wetfall-dryfall samplers located throughout the entire watershed. Results of the atmospheric sampling program are presented in Appendix A.

FIGURE 7


N
IRONDEQUOIT BAY
CENTRAL BASIN
ALLEN CREEK
THOMAS CREEK
THORNELL
▲ Local Raingauges
● NURP Basin Raingauges
1
2
3
4
5
6
7
8
9
10
11
12
13
ER
TC
SG
CR
TH

RAINGAUGE LOCATION MAP

SAMPLING PROCEDURES

For the most part, sampling of stormwater runoff was conducted at all monitoring locations by automated sampling equipment. The samplers were preset to obtain samples according to the expected response of the basin to rainfall induced runoff. Either the samplers were set to sample at equal time intervals or at a rate that would be related to the amount of flow passing the monitoring location. To insure that the samplers did operate according to plan, personnel from the MCHD were present at each monitoring site during storm events. This procedure allowed for the collection of samples during equipment malfunctions.

As indicated in Section 5, sampling was performed by a Manning sequential, discrete sampler. These units were factory modified to collect a one-liter sample. Samples collected using automatic equipment were checked and calibrated against depth integrated cross-section samples (collected by the USGS) over a range of flows using methods and equipment described by Guy and Norman (42). As indicated earlier, the sequential sampling interval was periodically adjusted according to the runoff response time of the basin being monitored. This allowed for sufficient samples being collected to adequately define the resulting pollutograph (plot of pollutant concentration vs. time).

Equally as important as the samples collected during storm events were the samples collected during baseflow conditions. These were collected at all sites using methods described by Guy and Norman to define non-storm or background concentrations at gaged sites (42). The baseflow samples provided the needed information to establish the annual phosphorus loading to Irondequoit Bay by defining the loadings to the bay during non-storm event sampling periods.

Sampling and streamflow equipment at all sites during this study were maintained by both USGS and MCHD personnel. All field collected samples were brought to the Monroe County Environmental Health Laboratory for processing. This processing involved filtering, splitting, preserving, and compositing.

ANALYSIS

Once sample bottles were logged in, labeled, split, preserved, and chilled as needed, samples were shipped to the USGS laboratory in Atlanta for all constituents listed under Items B-D in Table 7 for samples collected prior to 1981. Item A analyses were performed by the USGS sediment laboratory in Columbus, Ohio. Items E and F were performed by the MCHD laboratory immediately following sample processing. Additional analytical work, performed by the OBG laboratory, included TOC and DOC. Standardization and analytical procedures are also summarized in Table 7. In most cases these analytical procedures were consistent with those stated by the USEPA (43). For the 1981 sampling program, all items listed in Table 4, except for the sediment analyses (Item A) and the TOC and DOC tests, were performed by the MCHD laboratory.

To insure that accurate pollutant concentrations were measured and recorded by sampling at all monitoring sites, a Quality Assurance/Quality Control (QA/QC) plan was adopted for both field and laboratory analytical procedures. Details of the USGS's central laboratory quality assurance objectives have been presented by Skougstad et al. (44). All laboratory analyses conducted by other laboratories conformed to these same criteria of precision and accuracy.

Approximately 10 percent of all dollar and manpower requirements was devoted to quality assurance and control of field sampling and analytical determinations. The standards required by the USGS assured that strict standards of quality control and quality assurance were maintained.

Details of the USGS system of data analysis, validation, and reporting have been presented by Skougstad et al. (44). The procedures used in validating data included:

TABLE 7. STANDARDIZATION AND ANALYTICAL PROCEDURES

	Constituent	EPA Parameter Code	Preservation on Special Handling	Collection and Analytical Reference
A.	SEDIMENT			
	Suspended solids	00530	None	Skougstad et al. (44)
	Particle size analysis		None	Guy (45)
B.	INORGANIC			
	Specific conductance	00095	12 Hours, (Monroe County Lab)	Skougstad et al. (44)
	pH	00400	"	"
	Dissolved Solids	70300	Filtered	"
	Dissolved NO_2, NO_3-N	00631	", chilled, 72 hours	"
	Dissolved NH_3-N	00608	" " "	"
	Dissolved Kjeldahl-N	00623	" " "	"
	Total Kjeldahl-N	00625	Unfiltered, " "	"
	Dissolved Phosphorus-P	00671	Filtered, " "	"
	Total Phosphorus-P	00665	Unfiltered, " "	"
	Dissolved Sodium-Na	00930	Filtered, Acidified	"
	Dissolved Calcium-Ca	00915	" "	"
	Dissolved Magnesium-Mg	00925	" "	"
	Dissolved Potassium-K	00935	" "	"
	Dissolved Chloride-Cl	00940	"	"
	Dissolved SO_4	00945	"	"
	Alkalinity as $CaCO_3$	00410	"	"
C.	HEAVY METALS			
			Acidified	Skougstad et al., (44)
D.	ORGANIC			
	Dissolved Organic Carbon	00681	Filtered, Chilled	Goerlitz and Brown (46)
	Suspended Organic Carbon	00689	" " Silver Filter	"
	Chemical Oxygen Demand	00340	Acidified	"

TABLE 7. STANDARDIZATION AND ANALYTICAL PROCEDURES (CONT'D)

	Constituent	EPA Parameter Code	Preservation on Special Handling	Collection and Analytical Reference
E.	BIOLOGICAL			
	5-Day BOD	00310	Chilled, 6 Hours	Skougstad et al., (44)
	Ultimate BOD		" "	"
F.	BACTERIOLOGICAL			
	Fecal Coliform	31625	Filtered, Chilled, 6 hours 0.7mm Filter	Greeson et al. (47)

1. Ionic-Chemical balance
2. Relation of residue on evaporation to calculated dissolved solids
3. Specific conductance relation to total dissolved solids
4. Reliance on experienced and trained office and laboratory personnel

Data were permanently stored in the USGS computer file (WATSTORE). Verification of sample concentrations were performed if reported values were suspect or did not conform to USGS standards for validating data. At the end of 90 days, WATSTORE data were merged into the USEPA computer file (STORET).

All analyses performed by laboratories other than the USGS Central Laboratory were also required to conform to the minimum criteria of 10 percent QA/QC for all analytical procedures. Details of quality control procedures for non-USGS laboratories for the Irondequoit Bay NURP appear in Table 8. A summary of the results of the QA/QC program, as established for IBNURP, is presented in Appendix A.

TABLE 8. QA/QC PROCEDURES FOR NON-USGS LABORATORIES

Type of QA/QC Procedure	Frequency
Analysis of replicate samples	5% (one in twenty)
Analysis of spiked samples	Biannually
Analysis of unknowns (USGS-SWRS Program)[1]	Biannually

[1] Standard Reference Water Sample (SRWS) Program Schroeder et al. (48).

Reporting units for each constituent are listed under the appropriate references (see Table 7).

For this study, five storm events in 1980 and up to twenty-five events (depending on the site) in 1981 were monitored. Approximately 5000 samples were collected at the five IBNURP stations, which were subsequently composited into 650 for analyses.

FLOW MEASUREMENTS

Surface runoff was measured by rating open-channel controls according to methods described in Buchanan and Somers (49). Where possible, culverts or other suitable control sections were used to develop flow rating curves. All ratings were periodically checked and modified if necessary using USGS measurement techniques described by Carter and Davidian (50). As outlined earlier, several different types of flow monitoring devices were used at the monitoring sites. The instrumentation was originally calibrated during installation and was periodically checked against measured flows to assure accuracy and precision of recorded data.

Relative to flow monitoring, most of the field equipment operated satisfactorily with the exception of the Marsh-McBirney electronic head and velocity meter located at the East Rochester monitoring site. Numerous problems with flow recording were encountered with this unit throughout the duration of this project. To verify the accuracy of this unit under high flowrates, the USGS performed several dye dilution experiments on the East Rochester sewer system. Results of these tests indicated that the flow recording unit did not respond well to baseflow conditions (flows = 0.01 m^3/sec), but recorded flows reasonably well from baseflow to half-pipe flow conditions. Full pipe flow conditions were not tested.

Based on these dye dilution tests, it was decided that flow data obtained at the East Rochester site during 1980 were not valid and would, therefore, not be used in determining pollutant loadings. Flow data for 1981, although suspect in the high flow range (>1.00 m^3/sec), were considered reasonable, which allowed for the determination of runoff pollutant loadings.

The only other site which experienced some flow recording difficulties was Blossom Road. At the startup of the Blossom Road station, the effect of bay water level on the flowrate in the lower reach of Irondequoit Creek was not quantitatively known. Investigations by the USGS have led to adjustments to the original Blossom Road data base. The flow rating for this site will be improved through continued monitoring.

DATA MANAGEMENT

The collection of literally thousands of values involving rainfall, stream flowrates, and analytical results necessitated the implementation at the start of the IBNURP of a workable data management system. Without the numerous data verification checks performed by the USGS, MCHD, and OBG, obtaining reliable, accurate information would have been impossible.

Specifically for IBNURP, flow and quality data followed a circuitous path from initial field data collection until it reached the USEPA STORET data management system. The USGS and Monroe County Health Department (MCHD) collected field data and samples and processed it at their respective laboratories. All analytical data were eventually collated by the USGS and input into their data management system (WATSTORE). Flow and rain data were also reduced by the USGS and input into WATSTORE. Periodically, data were transferred automatically from WATSTORE to STORET by USEPA personnel.

For this study, data were stored in both the WATSTORE and STORET systems. Having data in two independent data banks allowed for maximum utilization by USGS, while fulfilling the USEPA program requirements that required having all data input into STORET.

As described earlier under methodology of approach, the local objective of this study was to assess the impact of stormwater runoff on Irondequoit Bay water quality. Therefore, the determination of runoff loads at the five subbasin locations was not the end of the program but rather provided the information needed to establish total basinwide loadings. The data obtained at the five network or subbasin sites provided the rationale for the subsequent evaluation of selected control measures. Before discussing the calculated subbasin loadings to the bay, a brief overview of the methodology of establishing stormwater runoff loadings is presented.

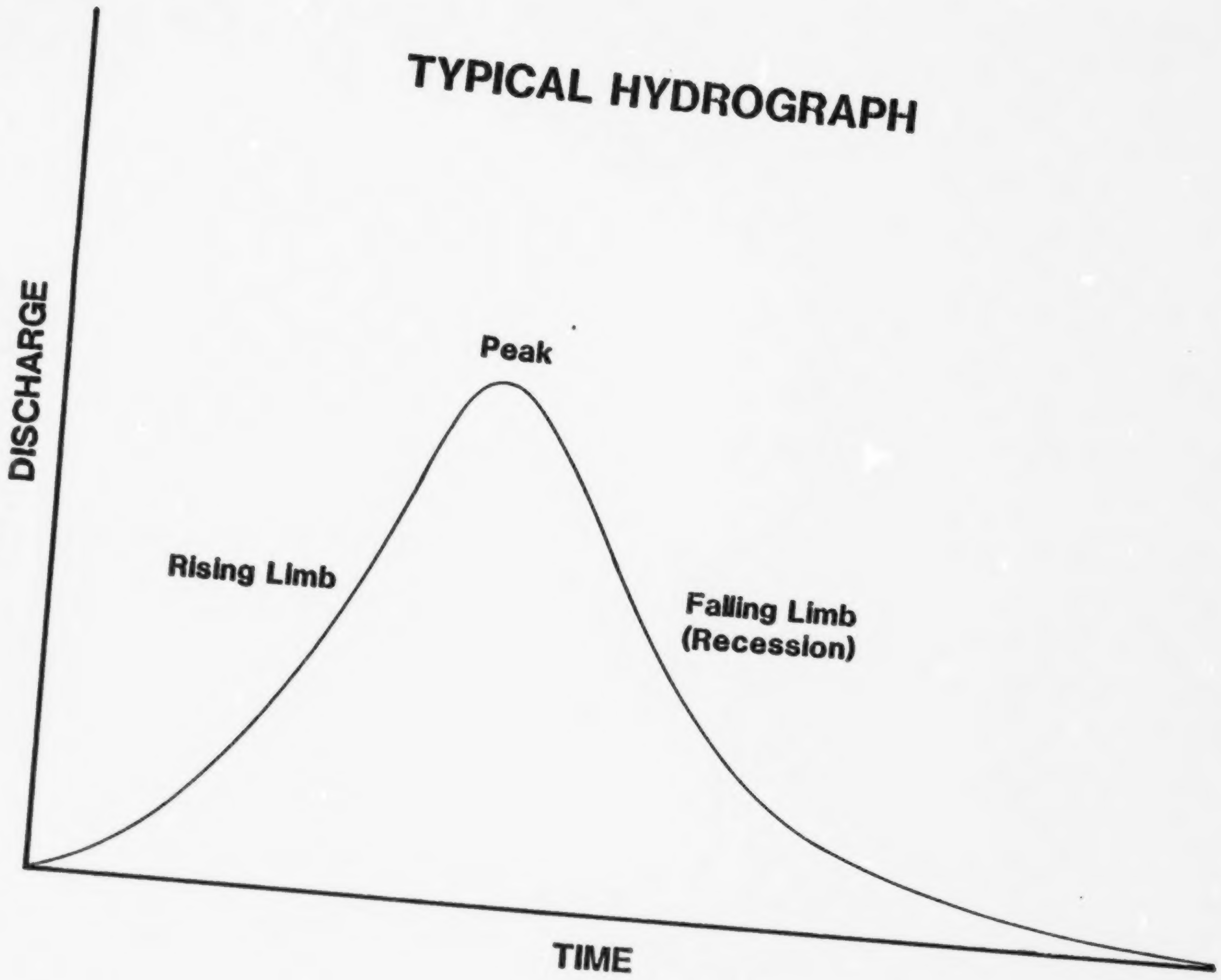
RUNOFF LOADINGS

The procedures involved in computing stormwater runoff pollutant loadings necessitate a brief discussion of rainfall and runoff. This material should aid in understanding the results of the sampling program conducted under IBNURP. A portion of rainfall is intercepted by natural vegetation with the remainder falling on the land surface. Water falling onto impervious surfaces tends to become immediate runoff, whereas, rain falling onto the ground is temporarily stored in surface depressions and begins to infiltrate into the underlying soils. As the soils reach their infiltration capacity, additional rainfall begins to run off the surface, thus becoming stormwater runoff.

Stormwater runoff is customarily analyzed by means of plotting (graphically representing) discharge against time. Such a plot is termed a hydrograph. Generally, discharge is given in units of m^3/sec with time given in hr. An example of a typical hydrograph is shown in Figure 8. As illustrated, a hydrograph can usually be divided into three separate segments: 1) the rising limb, 2) the crest or peak, and 3) the falling limb or recession. The actual shape of a hydrograph is dependent upon rainfall volume and intensity, size and surface conditions of the tributary watershed, and antecedent conditions. A hydrograph, therefore, represents the integrated effects of rainfall and numerous watershed characteristics.

Figures 9 and 10 illustrate these relationships. Figure 9 presents the actual hydrograph for the Cranston Road monitoring site, August 5, 1980 storm event. The type of runoff response is characteristic of a small residential watershed with well-defined stormwater conveyance

FIGURE 8



TYPICAL HYDROGRAPH

FIGURE 9

STORM HYDROGRAPH - CRANSTON ROAD

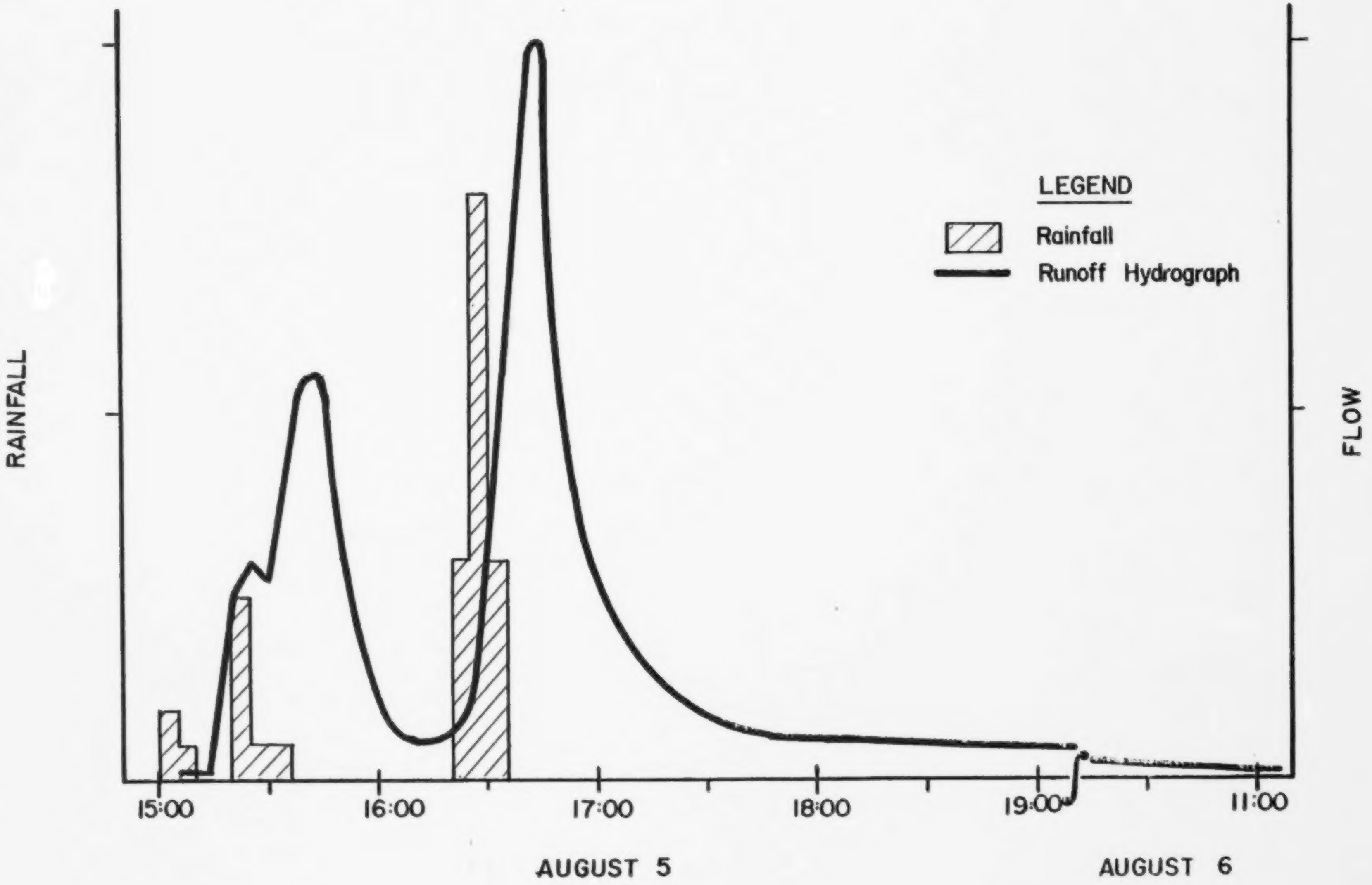
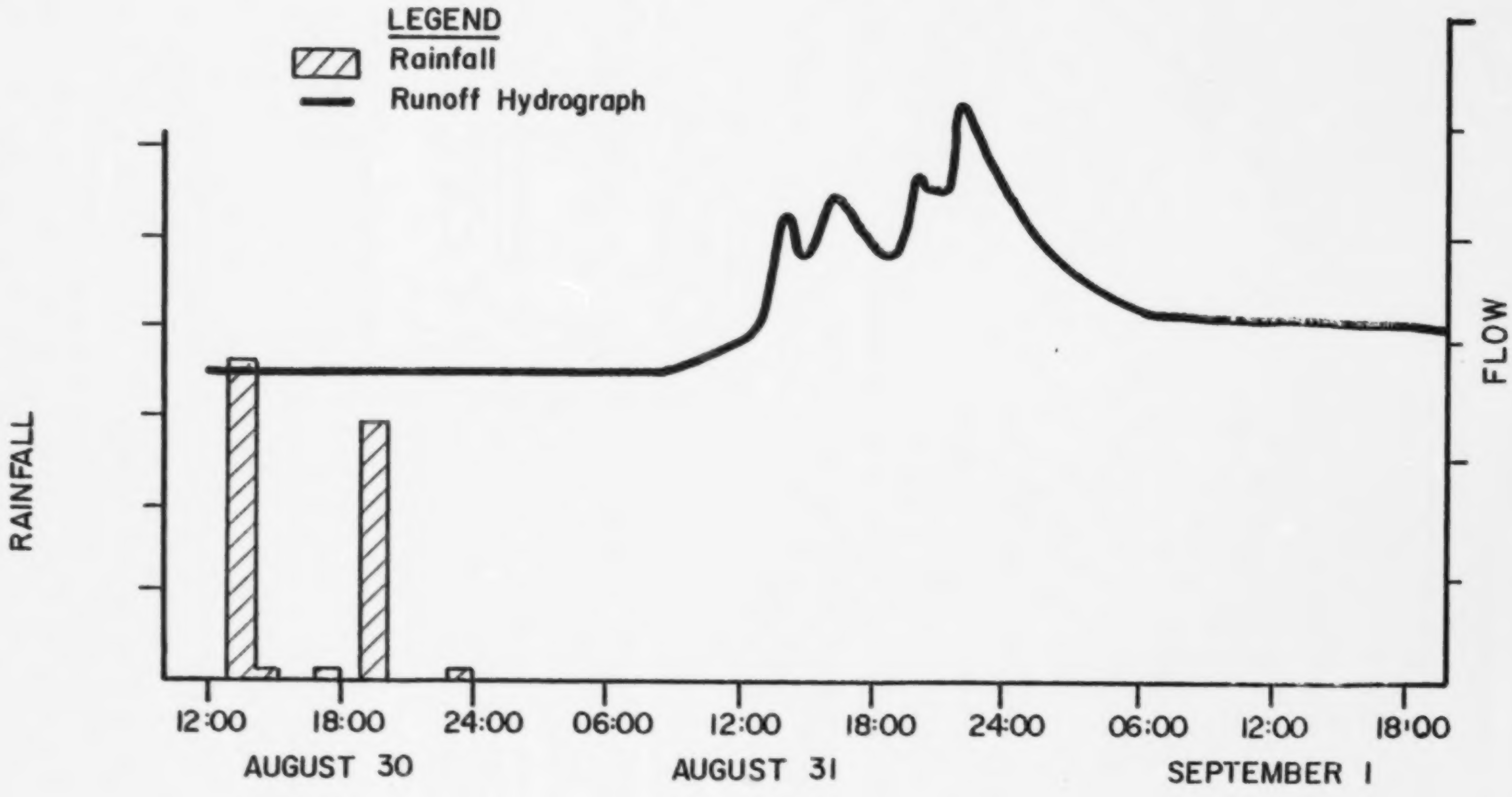


FIGURE 10

STORM HYDROGRAPH - THORNELL ROAD



channels. For such basins, runoff begins soon after the start of rainfall, continues upwards sharply to a peak, and decreases rapidly soon after the peak. Contrastingly, Figure 10 illustrates a hydrograph for a large agricultural watershed. As shown, runoff does not begin until a relatively long time after the start of rainfall, proceeds to a much flatter peak, and continues for a long period of time after rainfall ceases. In either watershed, the peak flowrate is dependent upon rainfall intensity and the size of the tributary drainage basin.

The term, runoff or pollutant loading, is defined as the quantity (mass) of a pollutant washed off the land surface as a result of rainfall induced stormwater. It is usually expressed in units of kilograms (kg). As it relates to the impact of phosphorus on the water quality of Irondequoit Bay, runoff loading is probably the most important indicator of pollution resulting from stormwater runoff. Indeed, as described in Section 7, the effect of stormwater runoff on bay water quality was modeled using the quantity of phosphorus discharged daily to the bay.

Runoff loadings were calculated by multiplying the concentration of a given pollutant, expressed as a mass per unit volume (mg/l) times the volume of runoff corresponding to that pollutant concentration. To compute the actual phosphorus loads to the bay, this procedure was complicated for several reasons. First, many samples were collected at each monitoring site during storm events which were subsequently composited (combined) into a fewer number of samples for constituent analysis. What runoff volume would be associated with each composite sample had to be determined. Second, on what basis would the field collected samples be composited also had to be determined.

For the entire IBNURP sampling program, the number of samples collected and subsequently composited for analysis was made on the basis of storm type. Storms were classified according to rainfall volume and maximum intensity. For IBNURP, four storm types were identified according to the conditions listed in Table 9.

TABLE 9. STORM EVENT DEFINITION

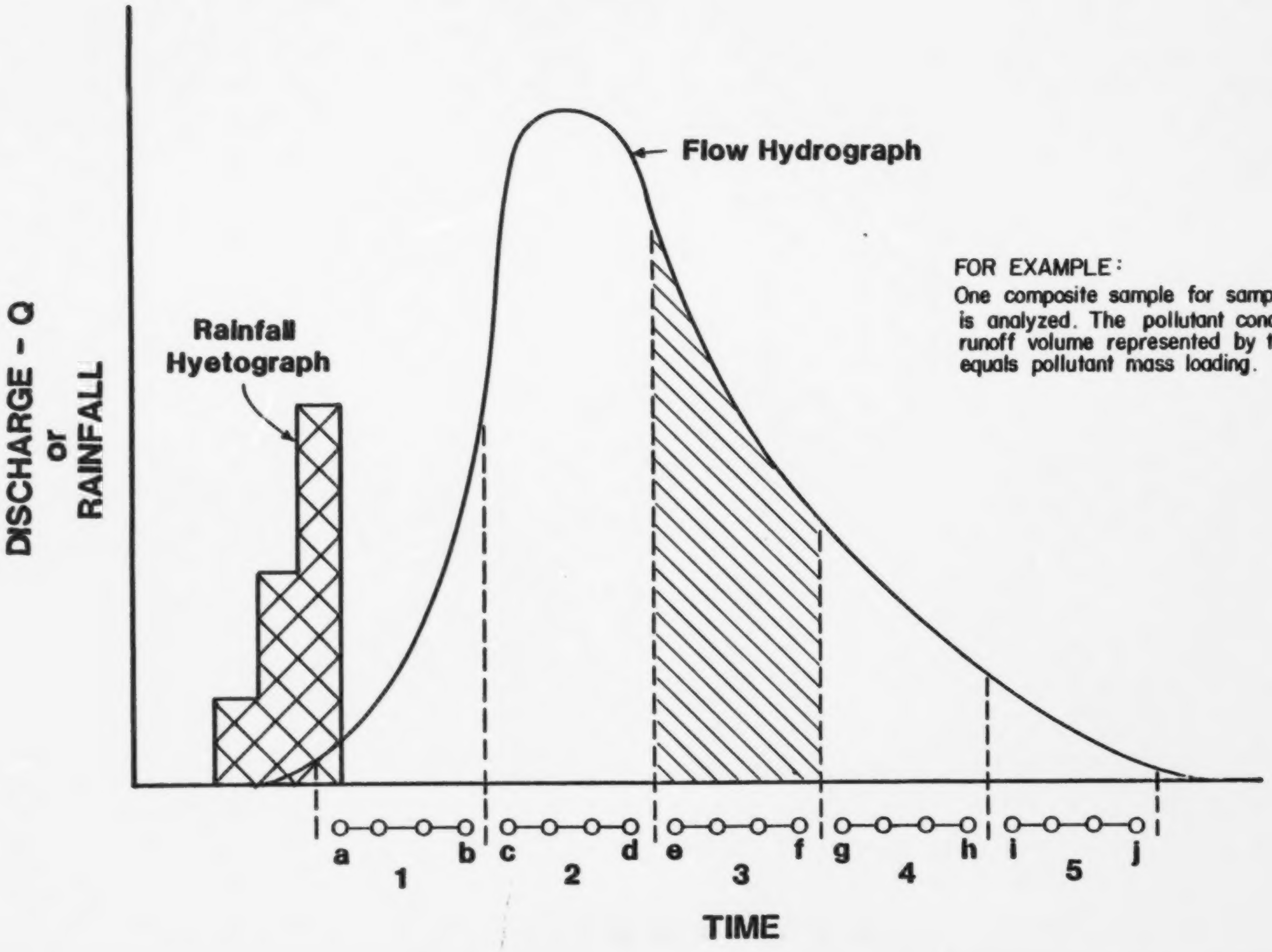
TYPE	CRITERIA	
1	Precipitation: intensity Weather Conditions:	>1.78 cm and/or >1.02 cm/hr Preceded by two weeks of dry weather
2	Precipitation (P): intensity	0.51 cm <P <1.78 cm and >0.51 cm/hr
3	Precipitation: intensity	>0.51 cm and <0.51 cm/hr
4	Precipitation: intensity	<0.51 cm/hr

On the basis of storm type, the sampling protocol at each monitoring site was modified to allow for collection of samples at a rate consistent with providing the most analytical data at minimum laboratory costs. In general, therefore, more samples were collected during the initial portion of the hydrograph from the point where the flowrate noticeably increased to a point shortly after the peak. Especially during large, intense rainfalls, the major portion of the total pollutant load is contained in this initial stormwater runoff. During the recession leg of the hydrograph, pollutant concentrations are usually significantly lower, since most of that pollutant has already been washed off the land surface. Thus, a less intense sampling effort is necessary for the latter portion of a runoff event.

Figure 11 illustrates the procedure used in determining the phosphorus stormwater runoff loadings. Although only phosphorus loads were calculated, the procedure could be extended to other pollutants. Referring to Figure 11, the small circles located along the time axis represent the time at which a discrete sample was collected. The vertical dashed lines represent the halfway points between sample times and also reflect the division of the number of discrete samples into composite samples. Discrete samples a-d, which comprise composite sample 1, would

FIGURE 11

SCHEMATIC OF MASS LOADING COMPUTATION


Flow Hydrograph
Rainfall Hyetograph
DISCHARGE - Q or RAINFALL
a
b
c
d
e
f
g
h
i
j
1
2
3
4
5
TIME

FOR EXAMPLE:
One composite sample for sampling interval e to f is analyzed. The pollutant concentration times runoff volume represented by the hydrograph equals pollutant mass loading.

represent the first time interval for which pollutant loadings would be calculated. The shaded area represents the runoff volume associated with the first time interval. To compute the phosphorus load for this interval, therefore, the phosphorus concentration for composite sample 1 would be multiplied by the associated runoff volume. Continuing this procedure for each such composite time interval and adding together the individual loads, a total storm loading was developed.

As with any sampling program, a small number of samples are unavailable for analysis due to equipment malfunctions and human error. Thus, it is unlikely that the entire hydrograph would be adequately represented by discrete samples. To account for such unavoidable gaps, several assumptions were made so that a total site pollutant load could be calculated. The assumptions included:

- If the collection time for the last discrete sample comprising a composite sample was within 1 hr of the collection time for the next discrete sample, then the time interval was defined by the midpoints of these discrete sample times.

- If the interval given above was more than 1 hr, then a separate interval was established that was not represented by an actual composite sample. In this case, a phosphorus concentration was estimated based on antecedent and subsequent concentrations and on changes in discharge occurring at this time.

- Since, in many instances, the recession leg of the hydrograph was not sampled to the point whereby streamflow returned to pre-storm conditions (to minimize the number of samples to be analyzed), additional time intervals had to be established to completely represent the entire hydrograph. The phosphorus concentrations associated with these intervals were estimated on the basis of baseflow phosphorus concentrations and antecedent storm conditions.

It must be noted that it was not intended to thoroughly sample the entire runoff volume for each storm event but rather to collect a sufficient number of samples to accurately estimate the total stormwater runoff pollutant loading. Phosphorus concentrations for samples collected during the rising limb of the hydrograph were initially assumed to be significantly higher than those for samples collected during the recession limb. Moreover, the change in phosphorus concentrations was assumed to become increasingly smaller throughout the overall runoff event. For these reasons, the sampling protocol described above was adopted. From the analysis of all of the analytical data, it was found that these assumptions were valid throughout the IBNURP sampling program.

NURP SITE LOADINGS

Runoff loadings from five NURP monitoring sites were developed to satisfy USEPA requirements that loadings be determined for different land use areas. Because of the importance on bay eutrophication, phosphorus was selected as the only parameter for detailed analysis. Analytical data from these sites for other parameters have been incorporated into the USEPA data management system for use by national NURP personnel. Loading data for such parameters as suspended solids (SS), total Kjeldahl nitrogen (TKN), and lead (Pb) are presented in Appendix A.

Tables 10 through 14 present the phosphorus loads for each of the five NURP monitoring sites for selected 1980 and 1981 storm events. No 1980 loadings for the East Rochester site are shown because measured runoff volumes (used in the calculation of pollutant loads) could not be substantiated. In addition to phosphorus loads, several other important parameters are also included in these tables. To better understand the significance of the phosphorus loads from a particular site as well as differences among the five sites, complete rainfall data, in terms of magnitude and intensity, are given. Such information is important since the magnitude of the phosphorus loadings and the average phosphorus concentrations on a storm event basis are dependent on rainfall depth and intensity. This is explained in greater detail under the general conclusions presented later in this subsection.

TABLE 10. PHOSPHORUS LOADS - CRANSTON ROAD NURP MONITORING SITE

Year	Date	Rainfall Intensity (cm/hr)	Rainfall Depth (cm)	Runoff Coefficient	Total Load (kg)	Unit Loading (kg/ha x 10^{-3})	Event Mean Concentration (mg/l)
1980	Aug 5-6*	4.88	1.96	0.24	0.2	3.2	0.268
	Aug 30-31	5.79	1.98	0.08	0.5	8.0	0.804
	Sep 1-2	0.61	0.25	0.10	No Sampling		
		9.75	6.78	0.17	3.8	56.2	0.473
	Sep 14-15	0.61	0.48	0.13	0.1	0.3	0.049
		0.91	0.23	0.10	0.1	0.1	0.025
		7.62	1.12	0.11	0.2	2.7	0.182
	Oct 25-26	1.22	7.47	0.27	4.3	62.5	0.305
1981	Feb 19-21	0.61	3.61	0.40	3.5	51.5	0.291
	Feb 23-24	1.22	2.06	0.42	1.5	21.7	0.186
	Mar 27	0.91	0.43	0.13	0.2	2.6	0.304
	Mar 30	1.52	0.79	0.17	0.5	7.8	0.468
	Apr 1	0.91	0.36	0.09	0.1	0.9	0.208
	Apr 14	2.13	1.02	0.13	0.2	2.9	0.187
	Apr 17-18	0.91	0.89	0.10	0.1	1.5	0.121
	May 10-12	2.74	1.19	0.16	0.4	6.0	0.294
		0.61	0.48	0.10	0.1	0.4	0.076
		0.61	0.64	0.10	0.1	0.6	0.066
	May 15-16	0.61	0.36	0.11	0.1	1.0	0.206
		0.91	1.37	0.14	0.2	3.1	0.133
	Jun 9	0.61	0.25	0.13	0.1	1.0	0.242
	Jun 10	1.22	0.30	0.14	0.1	1.5	0.268
	Jun 13-14	1.83	0.10	0.16	0.1	2.2	0.166
	Jun 21	0.91	0.99	0.14	0.2	2.9	0.205
	Jun 22	1.22	0.46	0.13	0.1	0.2	0.042
		1.83	1.07		0.2	2.4	0.140
	Jul 2	8.23	1.45	0.13	0.6	9.3	0.488
	Jul 20	2.74	2.46	0.13	0.5	7.6	0.259
		2.13	1.47		0.6	9.4	0.339
	Jul 28-29	1.83	2.49	0.11	0.3	4.3	0.138
	Aug 4-5	7.62	3.81	0.12	1.1	16.4	0.394
	Aug 10-11	3.35	0.51	0.08	0.1	0.8	0.172
		7.62	3.18	0.19	1.0	15.6	0.256
	Aug 13	2.44	0.48	0.07	0.1	0.9	0.207
	Aug 15	0.61	0.86	0.09	0.1	0.6	0.066

*Event on Aug 6 was not sampled.

TABLE 11. PHOSPHORUS LOADS - SOUTHGATE NURP MONITORING SITE

Year	Date	Rainfall Intensity (cm/hr)	Rainfall Depth (cm)	Runoff Coefficient	Total Load (kg)	Unit Loading (kg/ha x 10^3)	Event Mean Concentration (mg/l)
1980	Aug 5-6	7.92	3.61	0.18	4.5	61.8	0.947
	Aug 30-31	2.74	1.45	0.13	0.4	5.6	0.276
	Sep 1-2	14.94	6.81	0.20	2.5	34.1	0.242
		8.23	0.30	0.11	0.1	0.4	0.101
	Sep 14-15	3.05	1.91	0.16	0.3	4.0	0.118
	Oct 25-26	1.52	7.82	0.25	4.4	60.7	0.311
1981	Feb 19-21	24.69	3.53	0.54	2.1	28.6	0.101
	Feb 23-24	10.06	1.85	0.41	1.0	13.2	0.118
	Mar 27	1.22	0.58	0.18	0.4	4.6	0.243
	Mar 30	1.52	0.81	0.26	0.4	5.2	0.161
	Apr 1	0.30	0.25	0.30	No Sampling		
	Apr 14	1.83	1.09	0.21	0.5	5.9	0.206
	Apr 17	0.91	1.09	0.26	0.3	4.5	0.118
	May 10-12	1.52	2.29	0.19	0.7	9.2	0.137
	May 15-16	1.22	1.65	0.27	0.8	11.3	0.182
	Jun 13-14	2.13	0.79	0.15	0.2	2.3	0.164
	Jun 21	0.91	0.94	0.15	0.2	2.6	0.160
	Jun 22	3.35	2.26	0.16	0.5	7.0	0.169
	Jul 2	3.96	0.89	0.17	0.2	3.2	0.167
	Jul 20-22	4.57	4.06	0.18	1.0	13.4	0.192
	Jul 28-30	2.44	2.49	0.18	0.5	6.9	0.138
	Aug 4-5	3.66	2.64	0.17	0.6	8.0	0.164
	Aug 10-11	8.84	6.20	0.21	0.6	8.5	0.114
	Aug 13-14	1.83	0.41	0.14	No Sampling		
	Aug 15	0.91	0.94	0.24	0.2	2.8	0.110

TABLE 12. PHOSPHORUS LOADS - EAST ROCHESTER NURP MONITORING SITE

Year	Date	Rainfall Intensity (cm/hr)	Rainfall Depth (cm)	Runoff Coefficient	Total Load (kg)	Unit Loading (kg/ha x 10^{-3})	Event Mean Concentration (mg/l)
1981	Feb 23-24	1.52	2.29	0.07	0.5	3.6	0.210
	May 10-12	1.83	2.21	0.14	Insufficient Sampling		
	May 15-16*	1.22	1.85	0.16	1.1	7.1	0.204
	Jun 21	2.13	1.12	0.10	0.8	4.8	0.411
	Jun 22	1.83	1.57	0.13	1.0	6.8	0.288
	Jul 2	3.96	2.13	0.16	2.2	14.2	0.553
	Jul 20	3.66	4.14	0.16	5.8	37.3	0.528
	Jul 28-29	2.74	2.97	0.10	2.7	17.5	0.528
	Aug 4-5	4.88	2.97	0.12	1.7	11.2	0.291
	Aug 10-11	10.67	2.82	0.14	2.0	13.1	0.321

*First event on May 15 was not sampled.

*No loading data for 1980 is presented due to suspected errors in flow recording.

TABLE 13. PHOSPHORUS LOADS - THOMAS CREEK NURP MONITORING SITE

Year	Date	Rainfall		Runoff Coefficient	Total Load (kg)	Unit Loading (kg/ha x 10^{-3})	Event Mean Concentration (mg/l)
		Intensity (cm/hr)	Depth (cm)				
1980	Aug 5-6	4.98	3.25	0.02	Insufficient Data		
	Aug 30-31	1.22	0.84	0.01	1.5	0.2	0.082
	Sep 1-2	7.32	6.48	0.05	Insufficient data		
	Sep 14-15	2.03	2.46	0.02	6.6	0.9	0.114
	Oct 25-26	1.12	7.57	0.07	145	19.6	0.272
1981	Feb 19-24	3.05	5.69	0.07	221	29.9	0.141
	Mar 27	0.91	0.48	0.17	7.7	1.0	0.051
	Mar 30-Apr 1	0.91	0.97	0.09	14.4	1.9	0.054
	Apr 14	2.13	0.97	0.03	4.1	0.6	0.070
	Apr 17-18	1.22	1.19	0.04	7.6	1.0	0.066
	May 10-16	2.44	4.75	0.05	44.4	6.0	0.132
	Jun 9	1.74	0.53	0.01	1.5	0.2	0.108
	Jun 10	0.91	0.36	0.01	0.2	0.0	0.088
	Jun 13-14	2.13	1.14	0.03	7.2	1.0	0.109
	Jun 21-22	2.44	2.82	0.02	9.5	1.3	0.115
	Jul 2	3.66	1.30	0.04	10.6	1.5	0.119
	Jul 19-20	4.27	4.45	0.02	15.2	2.0	0.154
	Jul 28-29	3.05	2.54	0.02	13.5	1.8	0.185
	Aug 4-5	3.66	2.01	0.01	5.0	0.7	0.106
	Aug 10-15	13.41	3.94	0.03	17.2	2.4	0.099

TABLE 14. PHOSPHORUS LOADS - THORNELL ROAD NURP MONITORING SITE

Year	Date	Rainfall		Runoff Coefficient	Total Load (kg)	Unit Loading (kg/ha x 10^{-3})	Event Mean Concentration (mg/l)
		Intensity (cm/hr)	Depth (cm)				
1980	Aug 5-6	7.82	3.89	0.01	20.0	1.8	0.182
	Aug 30-31	1.93	1.83	0.01	7.5	0.7	0.110
	Sep 1-2	6.20	5.89	0.04	96.2	8.4	0.202
	Sep 14-15	5.18	3.40	0.01	14.7	1.2	0.085
	Oct 25-26	0.91	6.73	0.09	228	19.8	0.213
1981	Feb 19-24	1.22	4.17	0.32	6.49	56.3	0.223
	Mar 27	0.61	0.33	0.05	No Sampling		
	Apr 14	1.22	0.81	0.04	7.6	0.7	0.044
	Apr 17-18	0.91	0.61	0.17	8.2	0.7	0.033
	May 10-15	3.35	3.61	0.09	56.7	4.9	0.058
	Jun 9-10	0.91	0.38	0.01	3.2	0.2	0.037
	Jun 13-14	1.83	0.84	0.01	No Sampling		
	Jun 21-22	2.74	2.64	0.03	26.1	2.2	0.118
	Jul 2	8.53	1.35	0.01	5.9	0.6	0.091
	Jul 20	4.88	4.78	0.02	31.4	2.7	0.117
	Jul 28	2.74	2.21	0.02	17.2	1.5	0.100
	Aug 4-5	4.88	2.77	0.04	36.6	3.1	0.130
	Aug 10-15	8.84	6.35	0.04	57.2	4.9	0.079

Another important parameter calculated for each storm event was the runoff coefficient. In simple terms, the runoff coefficient (RC) is the ratio of the quantity of stormwater to total rainfall. It is a dimensionless quantity that relates the volume of stormwater runoff generated from a given watershed to depth of rainfall. Since it is a dimensionless quantity, both stormwater runoff and rainfall must be expressed in the same units, such as in m^3. To compute rainfall expressed in volumetric terms, rainfall depth is assumed to be uniform over the entire watershed. Multiplying rainfall depth by the size (in ha or km^2) of the watershed yields total rainfall volume.

The importance of the runoff coefficient was two-fold. First, it provided a check on the numerical calculations involved in determining the pollutant loadings. Obviously, more stormwater runoff could not be generated within a given drainage basin than that computed from basin size and total rainfall depth, assuming that all rainfall becomes runoff. Therefore, the runoff coefficient varies between zero and one. Second, the runoff coefficient provides some information regarding the amount of impervious areas within a given watershed. Although it varies according to different antecedent conditions and rainfall depth and intensity, it is directly related to the amount of impervious surfaces within the watershed. As any drainage basin becomes more impervious through urbanization, the greater the quantity and the faster the rate of stormwater runoff becomes. For this study, an average (by storm) runoff coefficient was sufficiently representative of varying basin conditions to use in the modeling effort described in the next section.

Another parameter useful in comparing the relative "pollutional strength" of a particular watershed is the term unit loading. For this study, unit loading was defined as the phosphorus load (as calculated by the methods already described) divided by the size of the drainage basin. By expressing the loading in this manner, the effect of basin size is removed. In this way, pollutant loadings can be compared to determine if stormwater runoff is different for varying land uses. The literature contains much information on these loading rates that can be used to estimate stormwater runoff loadings from areas without actually conducting a monitoring and sampling program.

The last parameter given in these tables is the term event mean concentration or EMC. Essentially, the EMC is the average pollutant concentration for a given site and storm event. It is defined as the phosphorus load divided by the total monitored streamflow volume passing a given monitoring location for the period represented by the hydrograph. It is important to note that there is a difference between total streamflow volume and quantity of stormwater runoff. If, for example, a monitoring station were located on a stream with no baseflow, that is, there is no flow except during storm events, then the EMC for this site would be the same whether streamflow or stormwater runoff were used in the calculation. However, for monitoring sites involving streams with baseflow, the calculated EMC would be different depending on whether total streamflow or only stormwater runoff were used.

Except for the Thornell and Thomas Creek monitoring sites, all other sites had a baseflow component that was so small in relation to stormwater runoff that it was considered negligible. For the Thornell and Thomas Creek sites, however, the baseflow component was large enough such that to calculate a true EMC for these particular locations, baseflow was subtracted from total monitored streamflow to arrive at stormwater runoff. This distinction was important, especially as it pertained to modeling the stormwater runoff loads. A similar situation was also true for calculating the runoff coefficient from sites that had a baseflow component.

Results of the runoff loading calculations in conjunction with a review of the parameters given in Tables 10 through 14 lead to the following generalizations:

1. A plot of phosphorus load versus rainfall depth indicates that the total quantity of phosphorus removed through stormwater runoff is directly related to the amount of rainfall. Furthermore, for a given amount of rainfall, the larger the size of the watershed, the greater the phosphorus load.

2. A review of the unit loading data reveals that the most polluting basin (the greatest phosphorus load per unit area) is East Rochester, followed by Thornell, Southgate, Cranston, and Thomas Creek. This result is not unexpected, since East Rochester represents the most urbanized watershed. Studies have shown that urban areas contribute more pollutants per unit area than do rural areas (51-53). The fact that Thornell, which represents a rural watershed, shows the second highest average unit loading likely results from the Thornell basin being almost exclusively in agriculture. Studies have shown that lands in active agriculture produce relatively high phosphorus unit loadings (52,53).

3. The highest average event mean concentration (EMC) was that for the East Rochester site with the lowest being observed at the Thornell watershed. This fact is again consistent with the findings of other studies whereby, the highest phosphorus concentrations in stormwater runoff have been associated with densely populated urban centers. However, it is important to realize that it is not necessarily the highest pollutant concentrations that have the most deleterious effect on the water qualtiy of Irondequoit Bay, but rather the total quantity of pollutants. Because of this, the observed EMCs for the five monitored watersheds were not of major importance to this study. The values are, however, useful in comparing the results of IBNURP to the findings of other studies throughout the country.

4. Runoff coefficients for urban watersheds were higher than those for rural watersheds. This finding is consistent with well established observations that indicate that the more impervious an area is, the more stormwater runoff is generated from that area. Moreover, runoff coefficients and EMCs are dependent on the number of antecedent dry days, as evidenced by their relatively large variations on a storm event basis. The differences, however, become unimportant when these

parameters are determined on an annual or seasonal basis. This point will be discussed in greater detail in Section 7.

To aid the reader in understanding these general conclusions, Table 15 is presented. This table presents the average values for several important calculated basin parameters and also presents a summary of these values given in relative terms.

TABLE 15. SUMMARY OF NURP MONITORING PROGRAM RESULTS

Basin	Basin Size(ha)	Basin (% of total)	Average Storm Event Phosphorus Load (kg)	Average EMC(mg/l)	Average Event Unit Loading (kg/hax10^3)	Average Event Runoff Coefficient
Thornell	11508	31.0(1)	78.9(1)	0.097 (5)	6.86 (3)	0.056 (5)
Thomas Creek	7387	19.9(2)	29.5 (2)	0.105 (4)	3.99 (5)	0.041 (4)
East Rochester	156	0.4(3)	1.81(3)	0.347 (1)	11.60 (2)	0.128* (3)
Southgate	72	0.2(4)	0.91 (4)	0.172 (3)	12.64 (1)	0.216 (1)
Cranston	68	0.2(5)	0.45 (5)	0.193 (2)	6.62 (4)	0.148 (2)

Notes:
1. Total basin size as tributary to Blossom Road (37065 ha).
2. Average values calculated as the arithmetic means.
3. Values in parentheses ( ) represent basin ranking for that parameter based on 1 = highest and 5 = lowest.

* It was not determined why the average runoff coefficient for East Rochester was so low considering the land use and the estimated percent imperviousness for the basin.

SUBBASIN LOADINGS

Based on flow monitoring and sampling conducted at Thornell, Thomas Creek, Allen Creek, and Blossom Road, subbasin phosphorus loadings were developed using data (as of May 1982) provided by the USGS. Table 16 presents these loadings for eight 1981 storm events. Loadings for 1980 events could not be quantified because of insufficient flow and/or analytical data at several sites. The selected 1981 event loadings represented the most complete data sets for each subbasin. All phosphorus loadings were calculated in a manner analagous to those for the NURP sites, as previously discussed. From Table 16, the following conclusions are presented:

1. Phosphorus loadings at all sites vary considerably throughout the year. No loadings, however, are available for the fall and winter months. The one February event shown represented a typical snowmelt/spring runoff condition occurring earlier in the year than normal.

2. Phosphrous event loadings to the bay (as represented by the load reaching the bay via Irondequoit Creek and measured at Blossom Road) varied from about 50 kg to nearly 2800 kg.

3. The largest single event loading was observed for the period of February 19-26. During this period, considerable rainfall combined with warm temperatures to produce a large volume of runoff. Since the ground had not yet thawed, infiltration was negligible with most of the rainfall and snowmelt becoming surface runoff.

4. Based on these monitored events, Thornell accounts for 12% of the phosphorus load measured at Blossom Road, Thomas Creek for 6%, Allen Creek for 31%, and Central for 51%. It is readily apparent that the two urban subbasins - Allen Creek and Central - account for approximately 82% of the phosphorus load, although they represent about 49% of the area tributary to Blossom Road. The rainfall associated with each of these storm events, however, was not uniformly distributed throughout the entire watershed. Rainfall distribution partially accounts for the variations in subbasin loadings for a given storm event.

TABLE 16. SUBBASIN LOADINGS 1981 STORMS

	Total P Loading (kg) by Site				
Date	Thornell	Central Basin	Thomas Creek	Allen Creek	Blossom Road
Feb 19-26	649 (23%)	821 (30%)	221 (8%)	1070 (39%)	2761
May 10-22	56 (14%)	214 (55%)	44 (11%)	77 (20%)	391
Jun 9-13	3 (7%)	40 (33%)	2 (4%)	3 (7%)	49
Jun 21-28	26 (12%)	103 (51%)	10 (4%)	64 (29%)	203
Jul 2-7	6 (2%)	230 (84%)	10 (4%)	29 (11%)	275
Jul 20-26	31 (13%)	77 (31%)	15 (6%)	127 (51%)	250
Jul 28-Aug 1	17 (10%)	91 (55%)	14 (8%)	44 (27%)	166
Aug 4-10	37 (18%)	34 (16%)	5 (2%)	134 (64%)	210
Aug 10-26	57 (13%)	245 (55%)	17 (4%)	123 (28%)	443
	2-23 (12)	16-84 (51)	2-11 (6)	7-64 (31)	

Notes:
1. TH = Thornell, CB = Central Basin, TC = Thomas Creek, AC = Allen Creek, BL = Blossom Road
2. All basin loadings except for CB calculated on the basis of measured data. BC loadings calculated as BL - (TH + TC + AC)
3. Numbers in parentheses represent the percent load for that site relative to Blossom Road

It is important to note the assumptions and limitations involved in the loading determinations. First, phosphorus loadings for Thornell, Thomas Creek, Allen Creek, and Blossom Road were calculated using monitored flow and analytical data. Loadings for the Central subbasin were calculated as the difference between the load at Blossom Road and the sum of the Thornell, Thomas Creek, and Allen Creek loads. As discussed previously, loading determinations involved streamflow readings. At Blossom Road, flow in Irondequoit Creek is influenced, to varying degrees, by the level of the bay. The resulting backwater effects cause difficulties in obtaining accurate flow measurements along the creek. Flowrates for the creek at Blossom Road were corrected for these effects. In any event, the phosphorus loadings for Blossom Road as determined in this study agreed closely with values provided by the MCHD (54). The methodology taken to develop the subbasin phosphorus loadings, as discussed herein, represented a reasonable approach to establishing average long term basinwide loadings.

To better understand the variations in subbasin loadings, Table 17 presents the rainfall data used in the loading calculations. The reader is referred to Figure 7 for raingauge locations. From Table 17, it is apparent that rainfall was not uniformly distributed over the Irondequoit Bay watershed for the given storm events. This non-uniformity of rainfall likely results in variations in phosphorus runoff loads among the subbasins in addition to other factors such as basin size and land use.

Although these local, non-recording raingauges did not provide rainfall intensity for each event, total rainfall depth was adequate for subsequent modeling efforts described in Section 7. Each subbasin was represented by several of the local raingauges in terms of establishing a uniform rainfall depth over each subbasin. The procedure used to average several rainfall depths to provide one uniform amount is outlined by Viessman (55). Model requirements dictated that only one representative rainfall depth for each subbasin be used.

TABLE 17. RAINFALL DEPTHS USED IN SUBBASIN ANALYSIS

Storm Dates (1981)	Subbasin TH	TC	AC	CB
Feb 19-26	5.38	5.38	6.65	6.50
May 10-22	4.34	3.61	3.66	3.94
Jun 21 -28	3.10	3.51	2.84	3.38
Jul 2-7	2.03	2.92	2.18	1.57
Jul 20-26	1.30	4.32	4.72	4.90
Jul 28-Aug 1	2.08	2.51	2.72	2.72
Aug 4-10	3.43	2.72	3.45	3.00
Aug 10-26	5.05	4.93	5.61	6.68

Note: All rainfall depths given in cm.

TH = Thornell Road
TC = Thomas Creek
AC = Allen Creek
CB = Central Basin

Before proceeding with a discussion of runoff modeling, it is important to note that the phosphorus loadings shown in Table 16 present stormwater runoff loads only. Loads from each subbasin generated during non-storm periods have not been included. Although storm event loads are considerably greater than those for non-storm periods, baseflow loads must be accounted for when total annual loads are to be determined. As will be quantified in Section 7, there are four components of annual phosphorus loads to the bay via Irondequoit Creek. They include:

1. Loads during the months of May through November
2. Loads attributed to spring runoff, assumed to be represented by the months of March and April
3. Loads during the winter months of December through February
4. Loads during non-storm conditions throughout the entire year.

Each of these periods during a year are characterized by varying physical conditions of the watershed. During the summer, the ground is relatively dry and, consequently, infiltration rates are high. In addition, many surface depressions exist which can hold a portion of stormwater runoff. Given these conditions, during the summer, the average runoff coefficient is lower except for storms in which rainfall intensities are so high that the water does not have time to infiltrate into the ground. Relative to phosphorus levels, because of the widespread use of fertilizers in the spring for farming and residential lawns, phosphorus levels in stormwater runoff are somewhat higher than at other times of the year.

During spring snowmelt, the ground is still frozen such that infiltration can be considered negligible. As a result, rainfall occurring this period results in immediate surface runoff. Consequently, runoff coefficients tend to be higher during this time of the year. Moreover, since pollutants have been able to accumulate on the land surface during the winter months with less removal through stormwater runoff, there is likely to be a large pollutant load associated with spring runoff.

It was initially believed that the amount of stormwater runoff during winter (December through February) is relatively small because snow falling onto the ground surface remains for long periods of time and only melts slowly. In addition, phosphorus concentrations were found to be low because of the inability of snow to remove surface pollutants. During periods of the year without snow cover, rainfall, because of its greater energy due to falling, can remove a large fraction of the accumulated surface pollutants. Because of these two factors, winter loadings were first thought to be small.

Based on measured loads, however, it was found that winter loads represent a significant portion of the annual load. This is because rainfall occurring during the winter months becomes immediate surface runoff due to frozen ground. Thus, when rainfall or snowmelt occur, water runs off carrying with it accumulated surface pollutants. In this way, large winter loadings can be generated. The important factor in determining the magnitude of this load is the condition of the ground, which is temperature related.

By definition, there is no stormwater runoff during baseflow (non-storm) periods. Phosphorus concentrations are likely to be relatively low because there are few physical processes occurring during this period that involve the removal of pollutants from the land surface.

Relative to phosphorus concentrations, statistical tests were applied to the calculated site event mean concentrations (EMCs) to determine whether or not seasonal differences were present. These tests were performed using statistical procedures outlined by Bowker and Lieberman (56). Based on these tests, the phosphorus EMCs for all five NURP sites did not exhibit seasonal variations. It should be noted, however, that these statistical tests assumed that the EMCs were normally distributed. Although the USEPA has indicated that preliminary analysis of EMC data from various NURP projects throughout the country has shown that they are log-normally distributed, statistical tests outlined by Hahn and Shapiro showed that the IBNURP EMC data can be regarded as being normally distributed (57). In any event, the limited data set available for statistical testing for IBNURP renders most statistical tests inconclusive. It will be shown in Section 7 that the modeling procedures used were such that the issue of normality was not important. How the calculated runoff coefficients were used in the conveyance modeling effort will also be discussed in the next section.

In summary, determination of total phosphorus loadings to Irondequoit Bay from the four major subbasins was important for two reasons, they were:

1. The values themselves were of interest when compared to historical and literature values. This comparison provided an evaluation of the validity of these data both by IBNURP participants and by national NURP representatives

2. These loadings served as the calibration data base for the runoff loading relationships described in detail in Section 7. The developed relationships subsequently served as the method used to evaluate alternative control technologies.

SECTION 7

RUNOFF AND WATER QUALITY MODELING

INTRODUCTION

The use of computerized mathematical models as planning tools in water quality management programs is becoming increasingly common. The basic purpose of any mathematical model is to simulate natural processes. In this study, two models were used for the following purposes: 1) to simulate or predict phosphorus loadings to the bay that would occur as a result of rainfall induced stormwater runoff (the runoff model), and 2) to predict changes in bay water column phosphorus concentrations as a result of changes in the internal and external phosphorus loadings (the bay model).

Although computer modeling of natural systems is currently achieving a high degree of precision and complexity, it is generally agreed that the simplest model that will do the job is usually the best. Today, there are many complex models that can provide valuable data for the design and final sizing of stormwater facilities. These models are, however, very expensive to set up and operate. The models selected for use in this study represent simple mathematical expressions (relationships) simulating natural phenomena to a reasonable degree. That is, they serve as tools in the planning and preliminary sizing of stormwater control facilities needed to improve the water quality of Irondequoit Bay. It must be realized that the use of these simple models in providing meaningful data at low cost will involve a sacrifice in precision for breadth of coverage. For a more comprehensive discussion on stormwater modeling, the reader is referred to two texts (58,59).

Before discussing the two models used in this study, it should be noted that for the interpretations of model output to be believable, it must be demonstrated that the model accurately represents the real system. The numerical accuracy of a model is not commonly a factor limiting model reliability (60). Rather, the major cause of errors in model output is the presence of errors and uncertainty in the input data. Simply stated, this means that model output is only as good as the input data.

To demonstrate that a given model is realistic, observed or measured system values are compared to corresponding values predicted by the model. Adjustments are then made to the input data so that the differences between observed and predicted values are minimized. In effect, the model is calibrated by reproducing a set of historical data with some acceptable level of accuracy. Before a model is considered valid or verified, its accuracy and predictive capability must be shown to lie within acceptable limits of error by comparing observed and predicted output using input data which are independent of the calibration data. Although the acceptability of model output is always at the discretion of the user, good agreement when modeling natural systems, as in this study, is generally achieved when predicted values are within ±20-30% of observed readings. The above described procedures were used for the runoff and bay models.

RUNOFF MODELING

The runoff modeling for this project was conducted in two phases. The USGS is developing a complex mathematical runoff model known as the Distributed Rainfall Runoff Routing Model (DR_3M). This model is complex in its mathematical description of the input variables that affect runoff and pollutant loadings. These variables include:

1. Drainage area size
2. Land use
3. Soil characteristics
4. Rainfall quantity and intensity
5. Antecedent dry days or number of days since the last measurable precipitation.

Development of the USGS model has been a major effort. At the time that a model had to be selected for this study, the DR_3M model had not yet been fully calibrated. The work involved in substantiating the validity of this model for the Irondequoit Bay watershed is continuing and is briefly described in Appendix A.

To quickly provide a convenient planning tool for assessing control technologies, an alternate modeling effort was undertaken by O'Brien & Gere that involved the use of much simpler mathematical model. Based on discussions with USEPA personnel in the Wastewater Research Division in Cincinnati, Ohio, a simplified stormwater management model had recently been developed and successfully applied, which could provide an inexpensive, flexible tool for the planning of stormwater abatement measures. The model, known as EPAMAC, was originally developed as part of the stormwater abatement program in San Francisco, California (61). This simplified model does not, however, eliminate the need for the DR_3M model, which will be used to confirm the initial findings and can be used to predict pollutants other than phosphorus.

Although the EPAMAC model addresses some of the major factors in determining stormwater runoff pollutant loadings, the mathematical relationships are very simplified. Such factors as in-stream processes involving particle settling and biological nutrient uptake are not addressed. This model, as well as all other models, is empirical in nature, thus requiring calibration and verification. In this project, the intent of the modeling effort was to convert rainfall (the model input) to pollutant loadings to Irondequoit Bay via Irondequoit Creek. The measured loadings at Blossom Road, which represent most of the basin, were calculated as a function of basinwide rainfall. The constants which were developed as a part of this calculation were related to the event mean concentration and runoff coefficient. For calibration and verification, 1981 measured storm data were used.

Relative to the basinwide modeling effort using EPAMAC, from Table 16, the storms of May 10, June 21, and July 28 were selected as calibration events. The average runoff coefficient (RC) and average event mean concentration (EMC) for phosphorus were obtained using the corresponding values for each of these storm events. Using these RCs and EMCs in conjunction with the total rainfall associated with each of the monitored storm events, as estimated from the local raingauge network, the model generated phosphorus loads which were subsequently compared to the observed loadings. Table 18 summarizes the basinwide runoff modeling results.

TABLE 18. BASINWIDE RUNOFF MODELING RESULTS

Storm Event Dates (1981)	Mode	Rainfall Amount (cm)	Rainfall Duration (hr)		Phosphorus Load (kg) Predicted	Phosphorus Load (kg) Observed
May 10	C	4.27	28		352	391
June 9	V	1.04	9		72	49
June 13	V	1.73	9		151	94
June 21	C	3.45	15		222	203
July 2	V	2.49	5		155	275
July 20	V	4.37	14		254	250
July 28	C	2.62	21		147	166
August 4	V	3.89	7		207	210
August 10	V	5.87	25		318	443
				Totals	1878	2081

Notes:

Model Inputs:

Runoff Coefficient = 0.072 (calculated as the arithmetic average of the RCs associated with the calibration storm events)

Event Mean Concentration = 0.154 mg/l P (Calculated in a similar manner to that for the RC)

C - Calibration
V - Verification

The calculated phosphorus load includes an estimated dry-weather component based on actual monitored flow and sampling data during dry-weather.

As shown, the total calculated and observed loads are within 10% of each other, whereas, there is much more variation between storm events. For establishing the credibility of this simplified runoff model, a close agreement between calculated and observed total loads for all storm events is more important than close agreement on an event basis. This is because the intent of the modeling effort was to estimate total annual or seasonal loadings and not loads on an individual storm basis. Such total loads were needed in determining the effectiveness of selected control measures, as discussed in Section 8. EPAMAC was known to be a model used for planning purposes (not for design purposes) whereby a determination of average annual pollutant quantities is essential. Close agreement for each storm event was not expected because such variations are likely related to various basin characteristics, antecedent weather conditions, and in-stream mechanisms that are not accounted for in the model.

Based on the close (within acceptable limits) agreement between total calculated and observed loads for nine monitored storm events, it was concluded that the EPAMAC model could adequately predict phosphorus loads for the Irondequoit Bay watershed. Since the number of storms used in this model validation process were few and only represented a relatively small portion of the year, the next logical step was to expand the use of the model to include all periods of the year. In this way, an annual phosphorus load to the bay from Irondequoit Creek could be determined.

The initial model calibration involved data for summer months only, since the most complete data set is for this period of the year. Although there was a shortage of data for other periods of the year, estimates for all required model inputs were made so that the model could be successfully applied to all seasons. Table 19 presents a summary of the model inputs necessary to predict seasonal loadings.

TABLE 19. SUMMARY OF SEASONAL INPUT DATA - BASINWIDE MODEL

Period of Year	Runoff Coefficient	Event Mean Concentration (mg/l)
Summer/Fall (May-Nov)	0.072	0.154
Spring (Mar-Apr)[1]	0.180	0.261
Winter (Dec-Feb)[2]	0.490	0.202

[1] Data for the spring period of year were based on calculated values for the Feb 19-24 storm event

[2] Data for winter loadings based on:
Runoff (estimated using monthly precipitation and measured streamflow) and measured phosphorus concentrations.

Baseflow - calculated from observed phosphorus concentrations and measured streamflow

These three periods were selected on the basis of data analysis. The relative consistency of the runoff coefficient and event mean concentration for the summer and fall months has already been mentioned. Secondly, as indicated by the storm loadings presented in Table 16, a substantial portion of the annual phosphorus load is associated with the spring runoff period. This period was selected as the months of March and April based on the review of historical climatological data collected by the U.S. Weather Bureau at the Monroe County Airport (62).

Although it was initially thought that runoff loadings during the winter months would be relatively small, phosphorus loads during this period were included in the analysis for completeness. From measured USGS streamflow data at the Thornell, Allen Creek, and Thomas Creek sites, U.S. Weather Bureau precipitation data, and analytical results of samples collected by the MCHD during the winter, representative EMCs and RCs were estimated. The magnitude of the calculated winter loadings indicated that they could not have been excluded from the analysis. The large winter loadings likely result because of several factors: 1) rainfall occurring during the period when the ground is frozen becomes immediate runoff and 2) since there are few rainfall events during the winter months, there are long antecedent dry periods during which pollutants can accumulate on the ground surface from atmospheric deposition.

Using the runoff coefficients and the event mean concentrations consistent with the period of the year in question as determined above, a long term simulation was conducted to approximate the annual phosphorus loading to Irondequoit Bay from Irondequoit Creek at Blossom Road. A 20 yr record of rainfall (precipitation) data obtained from the U.S. Weather Bureau for Rochester, N.Y. was used in the analysis. The period of record was from January 1954 through December 1973. Table 20 presents the annual phosphorus loading at Blossom Road for the 20 yr record. Loadings ranged from 9950 kg/yr to a high of 16450 kg/yr. The arithmetic average was 13020 kg/yr (35.6 kg/day).

TABLE 20. RUNOFF MODELING RESULTS-BASINWIDE ANALYSIS FOR 20 YEARS OF PRECIPITATION DATA

Year	Phosphorus Load from Runoff (kg) May-Nov	Mar-Apr	Dec-Feb	Total
1954	1850	3020	6870	14140
1955	2110	3230	4160	11900
1956	2020	3340	6970	14730
1957	1570	2000	5680	11650
1958	2560	1580	7210	13750
1959	1760	1850	10440	16450
1960	1560	1550	7740	13250
1961	1900	2990	5160	12450
1962	1990	1710	5860	11960
1963	1490	2330	4260	10480
1964	1160	2840	4580	10980
1965	1430	1730	6980	12540
1966	1490	1530	7790	13210
1967	2370	1330	3850	9950
1968	2300	1640	5550	11890
1969	1820	2050	6550	12820
1970	2660	1800	7640	14500
1971	1990	2080	9650	16120
1972	2650	2150	7490	14690
1973	1720	2710	6130	12960
Totals	38400	43460	130560	260420
Average (kg/yr)	1920	2170	6530	13020

Note: Totals include a baseflow load component of 2400 kg/yr (based on monitored flow and sampling data). This load was assumed to remain constant throughout the year and from year to year.

There are several important points that must be noted regarding the basinwide modeling effort. First, as indicated earlier, the EPAMAC model is a simplified mathematical representation of the rainfall-runoff-loading process to be used as a planning tool. Many of the basin and hydrologic factors that govern the actual physical processes involved in the runoff-loading relationship are not included in this model. Because of this, the model is more likely to better represent annual loadings than individual storm loadings. On an individual storm basis, many processes not accounted for in EPAMAC become significant. When the analysis is conducted on an annual basis, the values used for the input parameters tend to average or smooth out the variations observed on an individual storm basis.

Secondly, it must be assumed that the basin characteristics that presently exist and, upon which the runoff coefficients and event mean concentrations were based, have remained constant throughout the 20 yr period used in the modeling. Because of varying basin conditions, it is obvious that these predicted loads, using a constant value for runoff coefficient and event mean concentration, do not represent exact annual loads but only an approximation. This is not important, however, since it is the average predicted annual load that best reflects the adequacy of the model. Also, as will be indicated later, the relative rankings of the cost-effectiveness of selected control measures are not affected by the accuracy of the predicted average annual loads.

Based on data supplied by the MCHD, the average annual phosphorus load at Blossom Road had been estimated at 12500 kg/yr (34.2 kg/day) for 1981(63). The load predicted by the EPAMAC using a 20 yr rainfall record is within 4% of the previously estimated load. The good comparison between predicted and observed annual average loadings tends to validate the usefulness of this model under the basinwide application. It should be noted that the data analysis conducted by the MCHD was not complete. Portions on the year were not adequately represented by sampling data. Thus, it is likely that the actual average annual phosphorus loading at Blossom Road is somewhat greater than 12500 kg.

To better estimate the actual annual loading, the EPAMAC was applied to the four major subbasins which were described in Section 5. By analyzing the entire watershed using measured runoff coefficients and EMCs specific to certain portions of the basin, a better estimate of the total basin loadings should be obtained. For this analysis, it was assumed that the phosphorus load at Blossom Road was equal to the sum of the individual subbasin loads.

The next step was then to use the model to predict average loadings from the four major subbasins in a manner analogous to the basinwide calculations. This step is most important not only because of being more representative, but also because many proposed control measures would be more applicable to individual subbasins. The first step in the subbasin modeling effort was the determination of calibration and verification storm events. Three storms were selected to serve as calibration runs and five were subsequently used as verification events. For calibration runs, the May 10, July 20, and July 28 storm events were used.

After selecting the calibration storms, the next step was to establish the runoff coefficient and the phosphorus event mean concentration for model input. Although it was stated earlier that for the limited IBNURP data set, EMCs could be normally distributed, it is believed that with more data, the trend would be towards EMCs being log-normally distributed, consistent with USEPA preliminary findings (64). Thus, the geometric mean of all calculated EMCs for each subbasin was used in the modeling effort. In a log-normal distribution, the geometric mean, G, has the properties analogous to those of the arithmetic mean of a normal distribution (57). The geometric mean RC was also calculated for each of the four subbasins. Table 21 presents these data by subbasin.

TABLE 21. RUNOFF COEFFICIENT AND EVENT MEAN CONCENTRATION BY SUBBASIN USED IN RUNOFF MODELING

Subbasin	Runoff Coefficient	Event Mean Concentration (mg/l P)
Thornell	0.026	0.083
Thomas Creek	0.016	0.119
Allen Creek	0.100	0.159
Central Basin	0.080	0.423

Tables 22 through 25 present a summary of the calibration and verification model runs by subbasin. As indicated, there is generally good agreement between model predicted phosphorus loads and those measured in the field. The close comparison validates the usefulness of the model when applied to the individual subbasins. Again, as with the basinwide modeling analysis, variation between observed and predicted loads tend to be larger when considering individual storm events as opposed to total loads.

Following similar procedures described in the earlier sections dealing with the basinwide modeling effort, representative runoff efficients and EMCs for other periods of the year were established for each subbasin. These values are presented in Table 26. In this way, annual loadings could be developed based on the same twenty year rainfall record. Table 27 presents the subbasin modeling results using EPAMAC. As indicated, the sum of the subbasin loads is about 10% greater than the basinwide average annual phosphorus load. The greater loading indicated by the subbasin modeling analysis is more representative of the actual load to the bay via Irondequoit Creek than the basinwide modeling result. The difference is most likely related to sediment deposition and re-suspension occurring in the lower reaches of the creek that are indirectly accounted for in the subbasin model but are not in the basinwide modeling approach. This fact, along with the factors previously stated, render the subbasin loading results more representative. Therefore, for the control measure evaluations described in Section 8, subbasin loads were used.

WATER QUALITY MODELING

Before discussing the exact receiving water model used in the Irondequoit Bay NURP, a brief introduction may provide needed insight. One of the more difficult tasks associated with this study was the determination or prediction of bay water quality response to various combinations of external and internal phosphorus loadings. It is a relatively simple matter to make a general statement as to water quality;

TABLE 22. MODEL CALIBRATION AND VERIFICATION RESULTS - THORNELL SUBBASIN

Storm Dates (1981)	Phosphorus Loading (kg) Predicted	Phosphorus Loading (kg) Observed	Mode
May 10	41	56	C
June 9	5	3	V
June 21	30	26	V
July 2	6	6	V
July 20	42	31	C
July 28	20	17	C
August 4	24	37	V
August 10	56	57	V

	Predicted	Observed
Sum P Load (C)	103	104
Sum P Load (V)	121	129

C - Calibration

V - Verification

TABLE 23. MODEL CALIBRATION AND VERIFICATION RESULTS - THOMAS CREEK SUBBASIN

Storm Dates (1981)	Phosphorus Loading (kg) Predicted	Phosphorus Loading (kg) Observed	Mode
May 10	27	44	C
June 9	5	2	V
June 21	20	10	V
July 2	12	10	V
July 20	27	15	C
July 28	15	14	C
August 4	12	5	V
August 10	24	17	V

	Predicted	Observed
Sum P Load (C)	69	73
Sum P Load (V)	73	44

C - Calibration

V - Verification

TABLE 24. MODEL CALIBRATION AND VERIFICATION RESULTS - ALLEN CREEK SUBBASIN

Storm Dates (1981)	Phosphorus Loading (kg) Predicted	Phosphorus Loading (kg) Observed	Mode
May 10	86	77	C
June 9	5	3	V
June 21	66	64	V
July 2	47	29	V
July 20	99	127	C
July 28	54	44	C
August 4	108	134	V
August 10	108	123	V

	Predicted	Observed
Sum P Load (C)	239	248
Sum P Load (V)	334	353

C - Calibration

V - Verification

TABLE 25. MODEL CALIBRATION AND VERIFICATION RESULTS - CENTRAL SUBBASIN

Storm Dates (1981)	Phosphorus Loading (kg) Predicted	Phosphorus Loading (kg) Observed	Mode
May 10	145	214	C
June 9	21	40	V
June 21	119	103	V
July 2	78	230	V
July 20	175	77	C
July 28	93	91	C
August 4	108	34	V
August 10	228	245	V

	Predicted	Observed
Sum P Load (C)	413	382
Sum P Load (V)	554	652

C - Calibration

V - Verification

TABLE 26. SUBBASIN RUNOFF MODEL INPUT DATA

Subbasin	Period of Year	RC	EMC (mg/l)
Allen Creek	May-Nov	0.100	0.159
	Mar-Apr	0.840	0.258
	Dec-Feb	0.170	0.070
Thornell	May-Nov	0.026	0.083
	Mar-Apr	0.320	0.223
	Dec-Feb	0.090	0.040
Thomas Creek	May-Nov	0.016	0.119
	Mar-Apr	0.080	0.141
	Dec-Feb	0.080	0.050
Central Basin	May-Nov	0.080	0.423
	Mar-Apr	0.190	0.250
	Dec-Feb	0.220	0.070

TABLE 27. SUBBASIN MODELING RESULTS FOR 20 YEARS OF PRECIPITATION DATA

Year	Subbasin TH	TC	AC	CB	Subbasin Total	Basinwide Model Total
1954	6530	1530	6850	2370	17280	14140
1955	6800	1510	7210	2610	18130	11900
1956	7140	1620	7440	2530	18730	14730
1957	4670	1230	4940	2120	12960	11650
1958	4250	1340	4810	3010	13410	13750
1959	4670	1390	4990	2290	13340	16450
1960	4020	1200	4280	2110	11610	13250
1961	6400	1470	6710	2420	17000	12450
1962	4300	1240	4630	2500	12670	11960
1963	5170	1230	5400	2050	13850	10480
1964	5990	1280	6080	1750	15100	10980
1965	4270	1200	4490	2000	11960	12540
1966	3970	1190	4210	2050	11420	13210
1967	3650	1140	4150	2840	11780	9950
1968	4230	1260	4720	2780	12990	11890
1969	4850	1310	5170	2850	14180	12820
1970	4670	1420	5260	3100	14450	14500
1971	5080	1450	5440	2500	14470	16120
1972	5260	1480	5810	3090	15640	14690
1973	5940	1400	6210	2260	15810	12960
Totals	101860	26890	108800	49230	286780	260420
Annual Average (kg/yr)	5090	1340	5440	2460	14340	13020
(kg/day)	13.6	3.7	14.9	6.7	39.3	35.6

Note: All loads given in kg

however, in order to properly assess any proposed basin control measure, a quantitative assessment of water quality response must be made. There are several different concepts and parameters that could conceivably be used to make such an assessment. Each has its inherent strengths and weaknesses.

It should be recognized that water quality parameter(s) may be selected on the basis of results from a mathematical water quality model, review of historical data bases, convenience of measurement, or simply by people's perception of what constitutes improved bay water quality. With these thoughts in mind, the following parameters were initially presented for review and discussion by all program participants:

1. Secchi Disk Transparency - This parameter is a subjective measure of water clarity. It is measured by submerging a disk that is colored black and white into the water until a depth is reached at which the difference between black and white cannot be determined. This value, recorded in meters, is a good overall measure of water quality (29). Although transparency is obscured by such things as particulate matter, plankton, and algae, Secchi disk transparency is a parameter that is easily measured and one for which a large historical data base exists. It is, however, only a general measure of water quality, since it reflects changes in water quality related to factors other than stormwater runoff.

2. Floating Aquatic Plants - Plant microorganisms such as algae can create nuisance and odor problems. As a result, they are perhaps the most direct measurement of those things which should be controlled. However, algal measurements are difficult to make and generally, only a small historical base exists. As with the Secchi disk readings, algal productivity is also a measure of all the inputs to the bay, not only urban runoff.

3. Water Column Phosphorus - At this point, the commonly accepted belief is that algal growth in Irondequoit Bay is

phosphorus limited (11). As a result, the determination of water column phosphorus concentrations should provide a good measure of overall bay quality. This parameter is easily measured and a substantial data base exists. Once again, measurement of this parameter is not a direct measure of pollution resulting solely from urban runoff.

4. Other Water Column Parameters - It is possible to measure a variety of other parameters that are indicators of bay water quality. These include such things as pH, ammonia, nitrate, nitrite, alkalinity, and chlorophyll. All have their advantages and disadvantages similar to those for water column phosphorus.

5. Stormwater Runoff Phosphorus Loading - The monitoring program conducted under IBNURP provided the phosphorus inputs to the bay via Irondequoit Creek due to stormwater runoff. Since the purpose of this study was to evaluate various measures to control urban runoff, it would make considerable sense to use this parameter in assessing the impact of phosphorus on bay water quality. However, this parameter may not be directly related to the water quality of Irondequoit Bay. If, for example, phosphorus due to recycling represented a major source to the bay, then the use of phosphorus from stormwater runoff would be somewhat limited.

Even with all of these parameters to choose from, it may well be that the people who inhabit the area will make their own judgment as to bay water quality. Based on water quality as they see it, they will decide to swim or not to swim, to fish or not to fish. Although it may not be possible to objectively select one or more of the above parameters for assessing water quality, for this study, water column phosphorus was selected as the parameter for assessing the water quality of Irondequoit Bay.

Given that water column phosphorus is the criterion for assessing bay water quality, the next step was to establish target values. That is, what water column phosphorus levels are representative of desirable lakes with widespread recreational usage. Consistent with these levels, a maximum loading rate due to stormwater runoff could then be established. As stated in Section 4, a target value of 20-30 µg/l was selected as being representative of the water column phosphorus levels found in lakes with widespread recreational usage. The effect of internal recycling of phosphorus in Irondequoit Bay, however, may be pronounced. The exact processes involved and the magnitude of this problem have yet to be quantified. A parallel program, the Clean Lakes Study, is attempting to quantify this recycling process and is assessing control measures to reduce this loading (23). As mentioned in Section 4, the external phosphorus loading to the bay can be considered somewhat independent of the internal loading, at least in terms of establishing maximum phosphorus loading rates from stormwater runoff. The results from both programs must be reviewed together to determine the most cost-effective management plan for the bay.

With this brief overview in mind, the objective of the water quality modeling effort can be concisely stated as: to determine the water quality response of Irondequoit Bay to phosphorus loadings, both external and internal, under current levels of urban development within the drainage basin, with and without implemented management control options. Included in this effort was the development of sensitivity curves which indicate the water column phosphorus concentrations throughout the bay given various combinations of external and internal phosphorus loadings.

The water quality modeling effort was undertaken by the firm of Lawler, Matusky & Skelly (LMS) under subcontract to OBG. A detailed report of the modeling Engineers can be found in their report which has been issued separately from this document (65). A brief description of the model, however, is presented herein.

The purpose of the modeling effort was to mimic processes in Irondequoit Bay so that the average epilimnetic phosphorus concentration can be predicted given various external and internal phosphorus loadings. To accomplish this goal, it was necessary to understand how phosphorus cycles within the system; in other words, to determine the rate at which particulate phosphorus settled from the surface waters, to estimate the regeneration of phosphorus in the hypolimnion, and so forth. With this information, appropriate input values could be incorporated into the mathematical model to derive estimates of the phosphorus concentration. This output would then represent the direct response of the bay to changes in phosphorus loadings.

A steady-state modeling approach was developed representing the average phosphorus concentration during the July-August time period. This model was calibrated using existing data for the post-diversion years (1978-1980). The input parameters used to calibrate the model included the loadings and summer epilimnetic phosphorus concentrations during 1980 and 1981. These data were used because it most closely represented the current situation. Prior to 1980, loadings and concentrations were strongly influenced by discharges from numerous wastewater facilities. The summertime phosphorus values are most important since during this time period unsightly algal blooms occur while the bay is receiving the highest recreational usage.

The use of a steady-state model, however, prevents the direct determination of bay response to short term events, such as a thunderstorm. Instead, this model provides an estimate of average values over a longer period of time. Since algal blooms can occur as the result of large, sudden phosphorus loadings, it was desirable to also develop a dynamic model, if possible. A dynamic model requires much more data than a steady-state model because of its time variable approach to representing the dynamic behavior of phosphorus between the spring and fall overturns. In addition, a dynamic model is a much more mathematically complex model which attempts to precisely define many physical and biological processes occurring in the bay. The more processes are to be simulated, the greater the data base required. An attempt was made, however, to acquire these data during September, 1981. Although desired rainfall and runoff conditions occurred in the tributary watershed, the collected data were insufficient for model calibration. The wet-weather survey did provide, however, valuable information on the distribution patterns of pollutants discharged to the bay via Irondequoit Creek.

The fact that a dynamic water quality model could not be developed for this study should not be construed as failure in terms of assessing the impact of stormwater runoff on bay water quality. For planning purposes, as with the runoff model used for IBNURP, the selected steady-state model was adequate for predicting long term changes in water column phosphorus concentrations. There will likely be periodic storms that could lead to an algal bloom, but it is the general overall long term improvement in water quality resulting from decreased phosphorus loadings that is desired.

The steady-state model is of value as a screening device which allows an assessment of the magnitude of change that can be expected. In other words, it is a qualitative, not a quantitative tool. These factors further support the use of loading reductions rather than water quality response as the primary evaluation parameter for evaluating control technologies.

The steady-state model used in IBNURP required values for such important variables as phosphorus settling rate, vertical exchange rate, internal loads and longitudinal dispersion rates. Considerable insight for representative values was obtained from discussions with Professors Bannister and Holdren from the University of Rochester, whom are conducting research investigations on the bay (21,23). The modeling was conducted using the input parameters shown in Table 28. For those parameters with the greatest degree of uncertainty, a range of values corresponding to a maximum, current estimated level, and minimum values were used in the modeling effort. The results of all model runs are presented in Table 29 and shown in Figure 12.

TABLE 28. WATER QUALITY MODEL INPUT PARAMETERS

Epilimnion volume	21.51×10^6 m^3
Epilimnion depth	6 m maximum
Hypolimnion volume	23.3×10^6 m^3
Particulate phosphorus settling rate (deep basin only)	0.22 m/day
Vertical exchange rate	12, 33 and 55 kg P/day
Longitudinal dispersion:	
epilimnion	3×10^5 cm^2/sec
hypolimnion	100 cm^2/sec
External loads	10, 40, 70 kg P/day
Internal loads	42, 111, 180 kg P/day

Figure 12 shows the approximate relationship between epilimnion phosphorus concentration and external phosphorus loads for three different internal loading conditions. Thus, for an internal phosphorus load of 111 kg/day (66 kg/day from shallow sediments and 45 kg/day from the deep basin), the model predicts that a reduction in external loading from 70 to 10 kg/day would decrease the epilimnion phosphorus concentration by 56 µg/l (133 to 77 µg/l). That is, an 86% reduction in external loading results in a 42% reduction in the water column phosphorus concentration. Thus, for small changes in external loads, it is apparent that only small changes in epilimnion water column phosphorus concentration would occur.

TABLE 29. IRONDEQUOIT BAY WATER QUALITY MODEL RESULTS

Run Parameters								Results	
Total Phosp. Settling*	Longitudinal Dispersion		Vertical Dispersion	External Loads Irondequoit		Internal Loads		Average Phosphorus Concentration	
	Epil.	Hypo.	Hypo-Epil.	Creek	CSO	Shallows	Deep Basin	Epil.	Hypo.
^{z}(m/day)	(cm^2/sec)		(cm^2/sec)	(kg/day)		(kg/day)		(µg/l)	
0.22	300,000	100	0.02	10.0	8.0	12.0	30.0	30	90
0.22	300,000	100	0.02	40.0	8.0	12.0	30.0	57	130
0.22	300,000	100	0.02	70.0	8.0	12.0	30.0	85	171
0.22	300,000	100	0.02	10.0	8.0	40.0	30.0	53	126
0.22	300,000	100	0.02	40.0	8.0	40.0	30.0	81	167
0.22	300,000	100	0.02	70.0	8.0	40.0	30.0	109	207
0.22	300,000	100	0.02	10.0	8.0	66.0	30.0	76	160
0.22	300,000	100	0.02	40.0	8.0	66.0	30.0	103	200
0.22	300,000	100	0.02	70.0	8.0	66.0	30.0	131	241
0.22	300,000	100	0.02	10.0	8.0	80.0	30.0	88	178
0.22	300,000	100	0.02	40.0	8.0	80.0	30.0	115	219
0.22	300,000	100	0.02	70.0	8.0	80.0	30.0	143	259
0.22	300,000	100	0.02	10.0	8.0	120.0	30.0	122	230
0.22	300,000	100	0.02	40.0	8.0	120.0	30.0	149	271
0.22	300,000	100	0.02	70.0	8.0	120.0	30.0	177	311
0.22	300,000	100	0.02	10.0	8.0	12.0	45.0	31	115
0.22	300,000	100	0.02	40.0	8.0	12.0	45.0	59	155
0.22	300,000	100	0.02	70.0	8.0	12.0	45.0	87	196
0.22	300,000	100	0.02	10.0	8.0	40.0	45.0	55	151
0.22	300,000	100	0.02	40.0	8.0	40.0	45.0	83	192
0.22	300,000	100	0.02	70.0	8.0	40.0	45.0	110	232
0.22	300,000	100	0.02	10.0	8.0	66.0	45.0	77	185
0.22	300,000	100	0.02	40.0	8.0	66.0	45.0	104	225
0.22	300,000	100	0.02	70.0	8.0	66.0	45.0	133	266
0.22	300,000	100	0.02	10.0	8.0	80.0	45.0	89	203
0.22	300,000	100	0.02	40.0	8.0	80.0	45.0	117	244
0.22	300,000	100	0.02	70.0	8.0	80.0	45.0	145	284

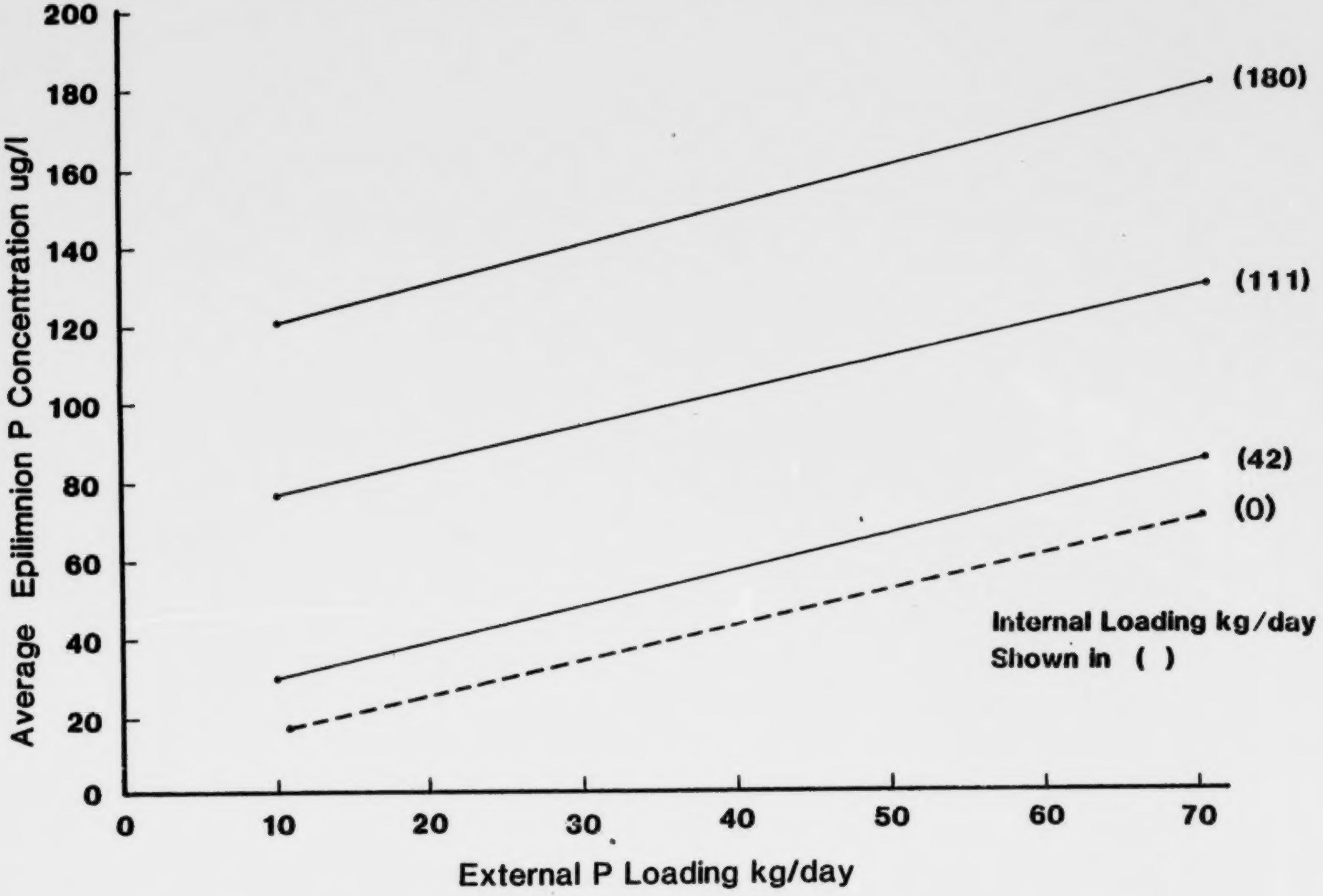
TABLE 29. IRONDEQUOIT BAY WATER QUALITY MODEL RESULTS (Cont'd)

Run Parameters								Results	
Total Phosp. Settling*	Longitudinal Dispersion		Vertical Dispersion	External Loads Irondequoit		Internal Loads		Average Phosphorus Concentration	
	Epil.	Hypo.	Hypo-Epil.	Creek	CSO	Shallows	Deep Basin	Epil.	Hypo.
(m/day)	(cm^2/sec)		(cm^2/sec)	(kg/day)		(kg/day)		(µg/l)	
0.22	300,000	100	0.02	10.0	8.0	120.0	45.0	123	255
0.22	300,000	100	0.02	40.0	8.0	120.0	45.0	151	296
0.22	300,000	100	0.02	70.0	8.0	120.0	45.0	179	336
0.22	300,000	100	0.02	10.0	8.0	12.0	60.0	33	140
0.22	300,000	100	0.02	40.0	8.0	12.0	60.0	60	180
0.22	300,000	100	0.02	70.0	8.0	12.0	60.0	88	221
0.22	300,000	100	0.02	10.0	8.0	40.0	60.0	56	176
0.22	300,000	100	0.02	40.0	8.0	40.0	60.0	84	217
0.22	300,000	100	0.02	70.0	8.0	40.0	60.0	112	257
0.22	300,000	100	0.02	10.0	8.0	66.0	60.0	79	210
0.22	300,000	100	0.02	40.0	8.0	66.0	60.0	106	251
0.22	300,000	100	0.02	70.0	8.0	66.0	60.0	134	291
0.22	300,000	100	0.02	10.0	8.0	80.0	60.0	91	229
0.22	300,000	100	0.02	40.0	8.0	80.0	60.0	118	269
0.22	300,000	100	0.02	70.0	8.0	80.0	60.0	146	309
0.22	300,000	100	0.02	10.0	8.0	120.0	60.0	125	280
0.22	300,000	100	0.02	40.0	8.0	120.0	60.0	152	321
0.22	300,000	100	0.02	70.0	8.0	120.0	60.0	180	361

* For shallows a value of 0.0 m/day was used

FIGURE 12

MODEL PREDICTED WATER COLUMN PHOSPHORUS RESPONSE
To Internal & External Phosphorus Loadings



Although Figure 12 suggests that external and internal loadings are independent, recent studies have shown that the release of phosphorus from the bottom sediments would decrease in response to decreased external loadings. Therefore, although Figure 12 appears to indicate that for large external loading reductions, only a marginal improvement in bay water quality would result, such reductions would likely eventually lead to a measurable improvement in bay water quality due to these combined effects.

Based on steady-state modeling, the relationship between epilimnion phosphorus concentration and external load for zero internal load is shown as the dashed line in Figure 12. Thus, if the present external load of 39 kg/day were eliminated, the bay would remain in a eutrophic state, since the epilimnion phosphorus concentration would be approximately 43 µg/l. This is well in excess of the 20-30 µg/l concentration considered desirable as discussed in Section 4. If, however, the external load were substantially decreased, the internal load would also likely decreased but only after a long period of time. Because of this, the bay would not show a marked improvement in water quality for some indeterminate (but long) period of time. With some form of bay intervention to shock the system, thereby reducing the internal load to almost zero, a reduction in the external load to a maximum of about 25 kg/day would maintain the bay in a mesotrophic condition. Thus, the water quality modeling effort can best be summarized by saying that current external phosphorus loads will perpetuate the eutrophic state of the bay but reducing the external load will allow the bay to reach mesotrophic status within a reasonable period of time, if some form of bay intervention is used to shock the system.

SECTION 8
TECHNOLOGY ASSESSMENT

GENERAL

The second primary objective of IBNURP, in addition to calculating urban storm runoff loadings, was to develop a management strategy to reduce these loadings in a cost-effective and publicly acceptable manner. The treatment or control of nonpoint source runoff loadings is not as straightforward as the treatment of point sources, such as municipal and industrial discharges. The number and diversity of options that are available are much greater for stormwater runoff than for these other sources. Therefore, discussion of treatment technologies and administrative arrangements for implementation begins with an outline of the approach that was used to develop a viable draft management plan.

Initially, a list of all existing treatment or control options was assembled from the literature, past experience, discussions with various regulatory agencies, the technical team, and the public participation subcommittee. These options were then subjected to a screening analysis using prior successful history as the primary evaluation criterion. In other words, if a control measure had not been successfully used in a full-scale application over a period of years, it was dropped from further consideration. This approach is entirely reasonable, since whatever control measures are ultimately selected, some local or regional governmental agency will have maintenance, operational, and/or administrative responsibilities. In this era of increasing concern for public spending, local or regional governments cannot subsidize extensive research or experimental efforts. It is equally unlikely that federal or state funds to finance prototype or demonstration treatment facilities for urban runoff will be forthcoming in the foreseeable future. These considerations have led to the conclusion that any control measures must be backed by a demonstrated, successful track record.

The detailed evaluation of various alternatives was based on the following criteria:

1. Performance
2. Cost
3. Implementability
    a. Technical
    b. Administrative/Institutional
4. Public Acceptance.

Performance was a difficult criterion to establish; however, as indicated earlier, it was ultimately decided to base performance on the reduction in bay phosphorus loadings from Irondequoit Creek as measured at Blossom Road. Phosphorus was selected for the following reasons:

1. It is presumed to be the limiting nutrient for algal growth in Irondequoit Bay.
2. It is easily and reliably measured and a large data base exists.
3. It is consistently found at levels that can be controlled.

Phosphorus concentration in the epilimnion of Irondequoit Bay was also used as a measure of performance. A mathematical model was developed that related bay water column phosphorus concentrations to external phosphorus loadings. As explained in Section 7, however, the model was not sufficiently responsive to reductions in external loadings to permit its use as a quantitative analytical tool. This limitation was not the fault of the model selected, but rather resulted from the unknown relationship between external and internal phosphorus loadings. Expected changes in Irondequoit Bay are, therefore, presented in a semi-quantitative manner to provide insight into potential improvements in bay water quality as a result of reduced external phosphorus loadings, which were used as the quantitative evaluation parameter.

A second mathematical model was used to predict the reduction in the phosphorus load conveyed by Irondequoit Creek, as measured at Blossom Road, that would result from the implementation of control measures throughout the watershed. This model was described in detail in

Section 6. The predicted effectiveness of individual control measures was based on a review of the available literature and the assembled expertise of the project technical team. The costs associated with various alternatives were based on information provided by review of the literature, manufacturers and vendors, engineering judgment, and past operating experience. Costs were estimated for both the initial construction and for annual operation and maintenance of the various control facilities.

Implementability means the predicted ability of the cognizant governmental agency to actually implement a control measure in view of cost, public opinion, and institutional constraints. These last two important criteria are often overlooked when evaluating control measures; however, public and political acceptance are essential factors that must be considered. This evaluation, conducted by the Center for Governmental Research, was performed by reviewing the available mechanisms for implementation that might be used and by interviewing town and county officials. Institutional considerations and the impact of public opinion are discussed in Sections 9 and 10, respectively. Public opinion is also vital to obtaining approvals or funding. This evaluation was performed by the presentation of initial draft reports to the public participation subcommittee and to the general public at a hearing.

INITIAL SCREENING

The candidate list of technologies and the initial screening are contained in this section. As stated earlier, this list was assembled from numerous available sources without regard to cost, performance, or other criteria. In this manner, even those technologies that might have only a remote chance of being implemented in the Irondequoit Bay watershed would be evaluated. These technologies are listed in Table 30 and are described in the following text.

TABLE 30. CANDIDATE LIST OF CONTROL TECHNOLOGIES

I. Best Management Practices (BMPs)

  A. "Housekeeping" Techniques

    - Street sweeping
    - Sewer flushing
    - Catchbasin/stormwater inlet cleaning
    - Solid waste management

  B. Preventive Techniques (Applicable for new or developing areas)

    - Porous pavement
    - Erosion controls
    - Chemical use controls
    - Stormwater infiltration

II. Structural Measures

  A. Storage Options (surface and subsurface)

    - Detention/retention basins
    - In-stream impoundments
    - Tunnel and cavern storage

  B. Treatment Options

    - Solids separating devices
    - Land treatment
    - Wetlands
    - Abandoned treatment facilities

Best Management Practices

Street Sweeping --

Street sweeping is a source management practice which addresses the removal of contaminants where they accumulate, before they are washed into the stormwater conveyance system. Sweeping efficiency depends on many factors; most notably, roadway surface, longitudinal slope, crown slope, and curb conditions, and the equipment operator. As part of the Rochester BMP study, an evaluation program was undertaken that consisted of flow monitoring and sampling at catchbasins for storm events under various street sweeping frequencies (40). Test areas received up to two and three times their normal sweeping frequency. Although results indicated that commercial areas contributed more pollutants to stormwater runoff than did residential areas, the overall conclusion was that increased street sweeping was not a cost-effective control measure for reducing phosphorus stormwater loads.

Another recent study indicated that phosphorus removal by street sweeping is costly and the overall effectiveness is low (66). These findings, in conjunction with the fact that only a small percentage of the overall Irondequoit Bay watershed is sweepable and that not all of the phosphorus in stormwater originates from roadways, substantiate the general conclusion that street sweeping for pollution control is not cost-effective.

Sewer Flushing --

This control measure would be applicable only if: 1) flushing were conducted on a sanitary sewer system whereby any materials removed by the flushing action would be discharged to a treatment plant for processing, or 2) flushing were conducted on a storm sewer system whereby the flows and scoured materials generated during the flushing operation could be diverted into a sewer system leading to a treatment facility before entering any receiving waters. Obviously, Alternative 1 does not apply, since stormwater runoff does not enter a sanitary sewer system. Only for a few areas within the Irondequoit Bay watershed does Option 2 apply.

Catchbasin/Storm Inlet Cleaning --

Catchbasin cleaning holds the potential for reducing the amount of accumulated pollutants from discharging into the sewer system during periods of rainfall. The effectiveness of this control technology for the Irondequoit Bay watershed is minimal, since almost all of the stormwater inlets in the watershed, including those within the City of Rochester, are not catchbasins but rather inlet structures. That is, there is no sump in these structures in which debris and pollutants can accumulate and be trapped from discharging into the sewer system.

Solid Waste Management --

Solid waste management can be an important way to reduce the amount of contaminants that can be removed and transported by stormwater runoff. This includes effective trash collection, leaf and garden debris removal and disposal, anti-litter laws, and the proper location and emptying of litter baskets. Existing programs for solid waste management should be evaluated and improved as necessary. However, these programs alone are not sufficient to significantly reduce the annual phosphorus load and, therefore, must accompany other methods for reducing stormwater loadings.

Porous Pavement --

Porous pavement is conventional asphalt which is applied in a manner such that rainwater can rapidly pass through to the underlying soils. In order for this technology to be most effective, the underlying soils must have adequate infiltration capacity. In developed urban areas, it is more likely that porous pavement would be applied over existing pavements to reduce the rate of stormwater runoff; whereas, in newly developing areas, porous pavement could be applied over permeable soils to reduce the volume of runoff through direct infiltration. For structural stability of the pavement section, the soil must not swell excessively nor heave at low temperatures.

The Rochester BMP report concluded that porous pavement held the possibility for reducing the volume of urban runoff when applied in new developments (40). The use of porous pavement is not encouraged for widespread application in the Irondequoit Bay watershed, however, given the high degree of existing development in the basin. This technology can be effective in newly developing areas but its effectiveness must be evaluated on a site-specific basis.

Erosion Controls --

A particularly important source of suspended solids in urban runoff is soil erosion from poorly managed construction sites, improperly landscaped areas, and stream banks. Erosion can be controlled using such techniques as maintenance of natural vegetation, soil stabilization, drainage channel protection measures, and use of detention basins at construction sites. Buffer strips around parking lots and other impervious areas, around areas of fertilizer and pesticide application, along roads, and around animal waste centers can also reduce the quantity of sediment and animal wastes contained in stormwater runoff from these areas.

Although the Soil Conservation Service (SCS) has no jurisdiction over the operation of construction sites, they do publish erosion control guidelines that have proved very useful to general contractors (67). The SCS also provides technical on-site assistance upon request. The New York State Department of Environmental Conservation (NYSDEC) does require that sediment eroded and washed into rivers and streams be controlled because of its detrimental effect on fish and wildlife. In many instances, the NYSDEC may require that various erosion control practices be implemented to limit the discharge of sediment from construction sites. Within the Irondequoit Bay watershed, several towns presently have drainage and/or erosion control ordinances.

For this method to be effective, both general contractors and the site inspectors from municipal agencies must be educated to the necessity and means of erosion control. It is felt that this technology offers considerable potential for phosphorus control, both in the suburban and rural portions of the watershed. For IBNURP, the effectiveness of erosion control methods has been limited to urban and suburban areas. Although erosion from agricultural lands can represent a significant fraction of the total, this form of pollution and remedial measures are being addressed by a agricultural study dealing with the southern portion of the Irondequoit Bay watershed (22).

Chemical Use Control --

Control over how the public uses pesticides, herbicides, insecticides, and fertilizers is difficult. Ordinances can attempt to regulate chemical use and public education through the manufacturers and distributors of these chemicals can also help. In general, however, such ordinances are difficult to enforce, since chemical use really depends on good will as well as an informed public. The fact that control is difficult, however, should not minimize an effort to educate the public.

Highway deicing chemicals are another source of pollution. Salt, in general, sodium chloride, is the most commonly used chemical for melting ice on highways. Other chemicals (hydrophobic substances) are available, through generally more expensive (59). Their use should be considered in light of their environmental effects as well as their cost. Proper storage that minimizes runoff is important as well as proper dosage. The use of sand to prevent skidding should be considered for the less frequently travelled roads with lower posted speed limits. The sand conveyed by stormwater runoff is inert and can be removed easily by any control measure involving sedimentation.

Gasoline stations should be inspected for outlets to the storm drainage system where high levels of gas and oil could be accidently or purposefully introduced to storm sewers. Proper disposal of service station wastes should be regulated and enforced. The public should be made aware that service stations will accept used motor oil for disposal, and that dumping such items into a storm drain is illegal.

Industrial locations where wastes or spills could accidently enter storm drains should be redesigned such that any catchment and underdrain liquids receive proper treatment and disposal. Industrial facilities can also be forced into implementing a spill prevention, control, and countermeasure plan (SPCC) utilizing existing state and federal legislation and/or local controls and ordinances.

From the standpoint of phosphorus, chemical use control ordinances will likely have little impact on total annual loadings to the bay. The exception would be if the use of fertilizers is banned. Although not likely effective in controlling phosphorus, chemical use ordinances can possibly be effective in limiting the discharge of other pollutants to the bay. The IBNURP public participation program described in Section 10 was a successful one and a natural extension of that effort would be continued public education through that process.

Stormwater Infiltration --

Many of the surface soils in the Irondequoit Bay watershed are sufficiently permeable such that large quantities of runoff could be discharged into the upper soils without causing surface flooding. In portions of the basin, streams and stormwater currently discharge to groundwater via natural mechanisms. These flows usually reappear at downstream locations. The soils through which stormwater passes can act as a natural filter to remove particulate pollutants. The soils also can act as absorption matrix for the removal of the dissolved species.

Stormwater can also be forced into deeper water bearing strata under pressure. This procedure, however, can introduce contaminants directly into groundwater supplies (59). In portions of the Irondequoit Bay watershed, the deeper aquifers are a source of drinking water. A thorough groundwater study would be necessary prior to consideration of this alternative. Since such a study is beyond the scope of this project, this technology was not evaluated further.

By constructing diversion and inlet devices, surface runoff can be directed into the soil. For this method to be viable, suitable subsurface conditions must exist and discharge must be limited to aquifers not used for drinking water supplies. In certain areas of the Irondequoit Bay watershed, these conditions are met. Since the potential for stormwater infiltration exists, this measure is evaluated in greater detail later in this section.

Seepage or percolation ponds are basins where collected stormwater is impounded for slow infiltration into the soil. The permeability of the soil is the most crucial design factor. Soils with very low permeability are unsuitable because the ponds would have to be excessively large. On the other hand, highly permeable soils may transmit the stormwater to groundwater without sufficient time for adequate filtration of the pollutants. The efficiency of such systems depend, therefore, on the soil and hydrologic characteristics of the given watershed.

There are many methods available for flow attenuation to decrease downstream flowrates and, therefore, to reduce the size requirements for downstream drainage structures. The control methods described in this section are such technologies that have been successfully applied. Swales are grass-lined drainage channels that are generally unobtrusive and fit well into rolling mown grass typical of many suburban developments. The grass itself reduces the velocity of stormwater decreasing its erosive potential. These channels are relatively inexpensive and easy to maintain. They also allow for increased soil infiltration.

Dutch drains are gravel-filled ditches (with an optional drainage pipe in the base) which improve the potential for stormwater infiltration. They also reduce the total volume of runoff from a given area which consequently leads to requiring smaller downstream storm drains.

Seepage pits are excavated areas filled with porous materials such as rocks or gravel. Whereas Dutch drains intercept and infiltrate immediate surface runoff prior to concentration, seepage pits receive runoff after preliminary concentration and allow for slow soil infiltration. Their advantages are similar to those for Dutch drains.

Other control measures that are effective in delaying runoff at its source are:

- Roof top and parking lot storage with controlled release
- Discharge of roof downspouts to infiltration/seepage pits
- Landscaping with terraces

- Use of perforated storm drainage conduits

Structural Measures

Detention/Retention Basins --

Simply stated, these facilities temporarily store surface runoff with subsequent controlled release at some later time. As used in this report, detention basins become filled during storm events but drain completely between storms. This is a contrast to retention ponds in which the water surface normally remains at a given elevation. These control measures have found widespread use in controlling peak stream flowrates to minimize flooding and to decrease the size of downstream drainage facilities. If properly designed, these facilities can be very effective in preventing flooding.

Over the past several years, emphasis has been placed on designing detention basins for multi-use purposes. It is usually possible to incorporate into the hydraulic design of these basins provisions for removing the contaminants found in stormwater runoff. Trap efficiency for different pollutants and durations of stormwater detention, however, has not yet been accurately established (68). A recent study indicates that detention basins can remove approximately 20% of the incoming phosphorus load (69).

Advantages associated with detention basins have been well documented (70). There are several disadvantages, however, such as the need to periodically remove the trapped sediment and litter. Considering all factors, detention of stormwater runoff through ponds and basins offers a convenient relatively inexpensive low maintenance solution to pollution from stormwater runoff.

In-Stream Impoundments --

The use of in-stream impoundments to retain a portion of stormwater runoff has long been one of the principal methods of flood control. The

Corps of Engineers (COE) identified six possible locations for such impoundments within the Irondequoit Bay drainage basin (20). It was the opinion of the COE, however, that these impoundments would not be a cost-effective method of flood control because of insufficient basin volumes to capture runoff from infrequent storm events. Thus, the project was dropped from further consideration by the COE.

In recent years, the pollution control benefits of in-stream impoundments have become more widely recognized. By retarding the flow and decreasing stream velocity, these impoundments enhance the settling of particulate material. The availability of sites, including the six identified above, within the watershed indicates the potential for this control measure.

Solids Separating Devices --

Swirl Concentrators -- Swirl concentrators are non-mechanical treatment flow devices that have been used as CSO treatment devices. The swirling action promotes liquid solids separation and allows for the discharge of cleaner wastewater. The retained solids must then be discharged to a sewer system for subsequent treatment. The use of such devices for urban runoff control would entail the discharge of the retained solids to a sanitary sewer system. These devices can effectively separate solids and floatables. Field, et al. reported 90% grit removal for particles greater than 0.3 mm, 80-100% settleable solids removal for solids larger than 1 mm, 18 to 55% suspended solids removal, and 33 to 82% total mass loading removals (71).

Swirl concentrators could be useful in the study area to reduce runoff loadings. It is likely that the greatest applicability will be as pretreatment devices in conjunction with other technologies and they will be evaluated as such later in this section. Swirl concentrators have also been used as an erosion control device to retain sediment washed off from construction sites (72).

Microscreening -- A microscreen is a rotating drum filter. The screen is generally of stainless steel and has a very small mesh size, typically 20-60 μ. Water enters one side and must pass through the screen to exit, trapping suspended solids on the filter. This process is one requiring high maintenance and energy. For these reasons, it was not considered further.

Dissolved Air Flotation -- Flotation following prescreening with chemical addition can provide good removals of suspended solids and BOD_5 (45-85% and 30-80%, respectively) and, interestingly, one of the highest phosphorus removal rates for a physical unit process (55%), as reported by Wanielista (59). This is an expensive, complex treatment process, however, that is likely not cost-effective and, therefore, will not be discussed further.

High-Rate Filtration -- High-rate filtration with prescreening and chemical addition is another expensive, sophisticated physical unit process that could be used to remove 50% of the total phosphorus in stormwater (59). For reasons similar to microscreening and dissolved air flotation, it is likely that this technology is also not cost-effective.

Land Treatment --

Overland flow is a relatively new treatment process, particularly for municipal wastewaters in the United States, although this process has been utilized for many years in other countries. This control technology involves spreading wastewater on gently sloping terrain planted with a dense ground cover vegetation that can withstand wet conditions. Wastewater trickles over a mat of vegetation and organic matter and into the surface soils (73). Renovation of the contaminated waters is accomplished by physical, chemical, and biological means. Although this technology is effective in removing certain pollutants, phosphorus removal is reportedly not particularly effective and may require additional pretreatment steps such as the addition of alum (73).

Other forms of land treatment include slow-rate land application and rapid infiltration. Slow-rate land treatment involves spray irrigation or flooding; whereas, rapid infiltration involves wastewater percolating through the soil and reaching groundwater. The wastewater is stored in some form of lagoon that has a pervious bottom discharging to deep, permeable soils.

Since all of these forms of land treatment represent relatively new, unproven technologies, in conjunction with the fact that much of the Irondequoit Bay basin is already highly developed, the effectiveness of this control measure within the study area was considered marginal.

Wetlands Treatment --

Wetlands have been identified as having a certain capacity for the renovation of polluted waters (74). Although wetlands are complex hydrologic, chemical, and biological systems, pollutants can be removed from stormwater by the wetland's capacity to absorb, adsorp, entrap, and settle the undesirable components of contaminated urban runoff. Various management techniques have been proposed to maximize the treatment potential of wetlands. Studies have been conducted to determine the rate at which plants within a wetlands remove dissolved nutrients by biological uptake (74,75). According to Hickok, microbial activity is the most important mechanism for phosphorus removal (73).

Results of various studies indicate that biological uptake of phosphorus with plant harvesting is a promising control technology. However, as yet, it is not a proven control measure. Because of the existence of a large wetlands area immediately upstream of Irondequoit Bay, this technology offers great promise in this watershed. For this study, wetlands treatment through biological uptake was not considered but that phosphorus removal through the process of sedimentation would be investigated. It is this mode of treatment upon which the cost-effectiveness of wetlands utilization for stormwater pollution control is based. This is described in detail later in this section. It should be noted that utilization of these wetlands as a sedimentation basin necessitates the construction of a flow regulating control structure at the outlet to the wetlands to provide sufficient detention time for particle settling.

Problems with using the wetlands as a treatment alternative may arise from motor oil, gasoline, pesticides, and other chemicals contained in stormwater runoff that are toxic to any part of the complex wetlands food chain. The potential for this can be assessed after the runoff is carefully characterized and, if necessary, minimized through public education.

Abandoned Treatment Facilities --

It was initially thought that the abandoned sewage treatment facilities that were taken out of service when the Cross-Irondequoit Tunnel system was completed could be used to treat stormwater runoff. These fourteen facilities were in various stages of disrepair, but could potentially be used for storage or treatment by sedimentation of at least the more highly contaminated first-flush portion of urban runoff. However, after discussions with those personnel from the Monroe County Department of Engineering responsible for maintaining these former STPs, it was determined that these facilities were demolished to the extent that they are no longer usable (76).

As a result of this initial screening, the following control technologies were considered to have sufficient potential to merit further detailed consideration:

1. Wetlands Treatment
2. In-Stream Impoundments
3. Erosion Controls
4. Stormwater Infiltration
5. Swirl Concentrators

CONTROL MEASURE EVALUATION

Wetlands Treatment

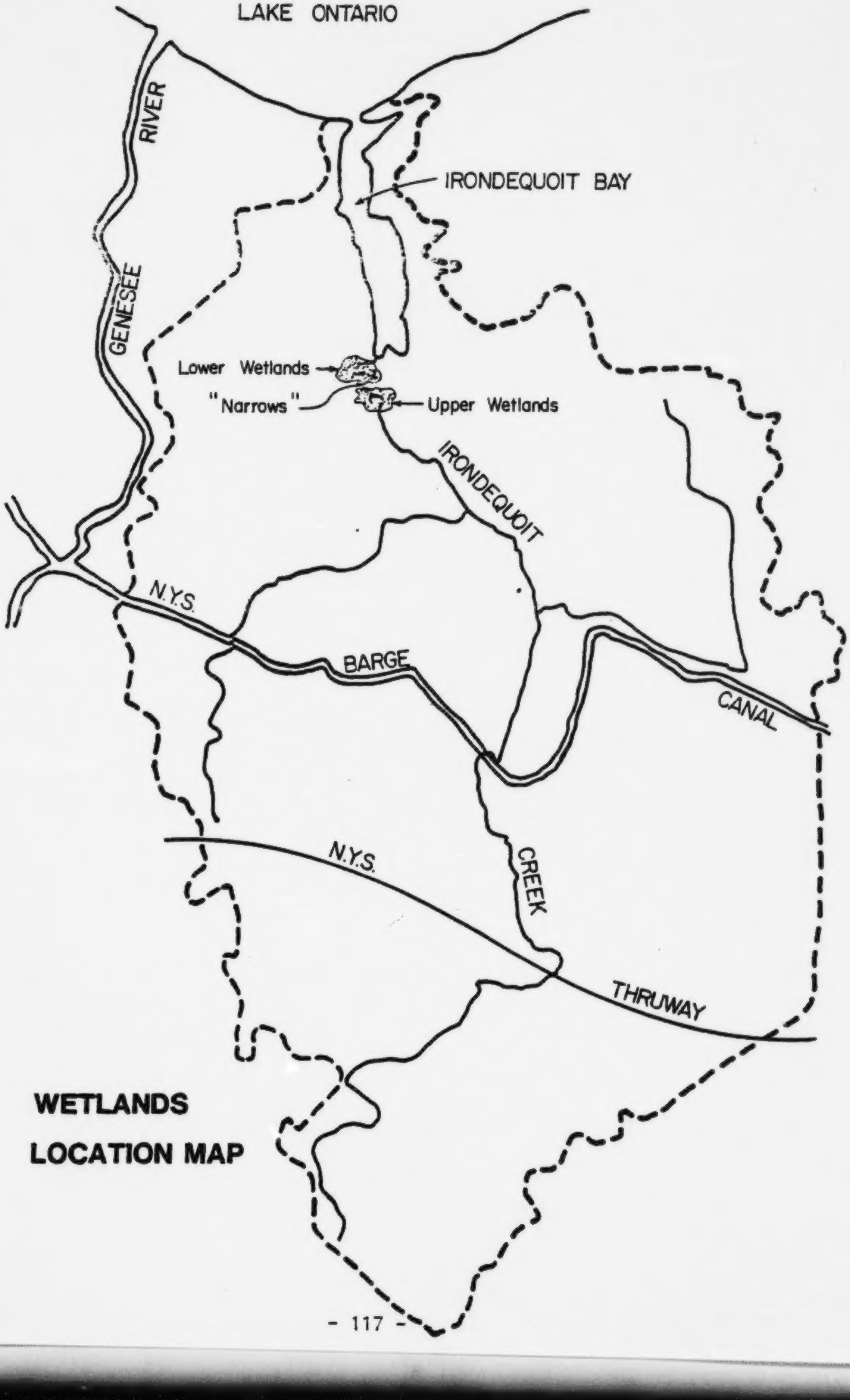
Description--

There are extensive wetlands that extend from Browncroft Boulevard to the mouth of Irondequoit Creek at Empire Boulevard. These wetland areas are shown in Figure 13. These wetlands can best be typlified as a cattail marsh, although numerous other common plant species as well as various wetland birds, animals, and fish also inhabit the area.

The entire wetlands area is divided into two distinct regions by a headland which extends most of the way across the wetlands to produce a narrow channel. This narrow channel area is called the Narrows and divides the wetlands into upper and lower areas, which are approximately 65 and 77 hectares (ha), respectively. From topographic maps, it can be seen that the water elevation in the wetlands can be raised only about 1.5 m without flooding the lower portions of Ellison Park (at the southern end of the wetlands). Thus, this elevation was the limiting factor in determining available storage.

Use of the wetlands would involve the construction of a flow regulating control structure at either the Narrows or at Empire Boulevard. When storm flows from the Irondequoit Bay watershed reach the wetlands, the control structure would be activated. An inflatable dam or adjustable weir would retain the flow in the wetlands to a maximum depth of 1.5 m. Any flows in excess of the available storage capacity would pass through the control structure and, therefore, prevent upstream flooding. The stored flow would be gradually released over a period of days. Under normal dry-weather flow conditions, the control structure would offer no impediment to stream flow. Operated in such a manner, this control technology would likely not have any significant adverse impact on the resident biological communities.

FIGURE 13


LAKE ONTARIO
IRONDEQUOIT BAY
GENESEE RIVER
Lower Wetlands
"Narrows"
Upper Wetlands
IRONDEQUOIT CREEK
N.Y.S. BARGE CANAL
N.Y.S. THRUWAY

WETLANDS LOCATION MAP

Since the use of the wetlands is based on sedimentation as the primary treatment process, the ultimate impact will be the loss of this area as a wetlands. In a way this process is inevitable, since stream sediment transport naturally leads to loss of available storage through sedimentation, until the wetlands character is lost. Without a control structure, this natural process would likely take many hundreds of years, while under this scenario, the process is estimated to be complete in less than a hundred years. The impact of accelerated sediment deposition can be minimized, however, through periodic dredging of the wetlands. Prior to actual implementation of this control measure, an extensive environmental review as outlined in the regulations issued pursuant to the State Environmental Quality Review Act (SEQR) would be required.

Effectiveness--

As stormwater enters the wetlands via Irondequoit Creek, stream flow velocity is substantially reduced which causes settling of particulate matter. Thus, the major phosphorus removal mechanism is the settling of the particulate fraction of the total phosphorus load. Other removal mechanisms that are likely to occur include the adsorption of dissolved phosphorus on particulate matter, the mineralization of orthophosphate into insoluble forms, and the direct biological uptake by the resident plant communities (74).

Theoretically, it is possible to remove a substantial portion of phosphorus from the basin by harvesting the cattails within the wetlands. It is well known that cattails provide for a large biological uptake of phosphorus during their growth cycle (77). When the cattails decay, a fraction of the phosphorus is released back into the soil and water. Harvesting offers the potential to remove this phosphorus before it is re-released to the waters. This concept, however, has not been successfully applied on a wide-scale basis. Thus, it will not be considered further at this time. It does remain, however, as a long-term consideration which could be utilized when the state-of-the-art adequately develops to support its application.

Since the late 1800's, many attempts have been made to develop an accurate and reliable method of estimating the removal efficiency of sedimentation basins. Theoretically, deposition of sediment (particulate material) in a reservoir will be dependent on the soil (particle) characteristics, the detention time in the basin, the depth of fall, and the sediment concentration of the incoming flow (68). Because of the variability in these parameters, methods of estimating sediment removal have been difficult to quantify. In fact, no single trap efficiency method has been developed which is suitable in the design of reservoirs and sediment detention basins (68). This is especially true when average annual removal efficiencies are estimated.

An empirical relationship was developed by Brown based on observations and data collected from over twenty-five normally ponded basins (68,70). There was considerable scatter in the data indicating that there is little correlation between the input parameter and the trap efficiency. Since better methods do not exist and because actual design is not needed, Brown's method was used to estimate the average annual removal of particulate material. The following formula was used:

$$\text{Annual Sediment Removal (\%)} = 100\left[1 - \frac{1}{1 + 0.021\,(S/A)}\right]$$

where S = available storage in m^3

A = drainage area in ha

The monitoring data collected at Blossom Road showed that the ratio of particulate to total phosphorus was about 0.67. Thus, annual phosphorus removal for the wetlands used as a sedimentation basin can be calculated as follows:

Quantity of Phosphorus Removed =
0.67 × % Sediment Removal × Phosphorus Loading

Based on this formula, estimates for the annual removal of phosphorus for the upper and lower wetlands were developed and are presented in Table 31.

TABLE 31. PHOSPHORUS REMOVAL IN THE WETLANDS

Area	Size of Wetlands (ha)	Available Storage-S (m^3)	Drainage Area-A (ha)	Annual Sediment Removal (%)	Annual Phosphorus Removal (kg)
Upper Wetlands	65	987,000	37,300	36	3460
Lower Wetlands	77	1,170,000	37,300	40	3840
Total Wetlands	142	2,157,000	37,300	55	5280

The drainage area is that portion of the bay watershed tributary to Irondequoit Creek and measured at Blossom Road, for which the annual phosphorus loading was estimated as 14,340 kg/yr.

Costs--

The capital costs for the construction of control structures at the "Narrows" and at Empire Boulevard have been estimated as follows:

The Narrows -- A construction cost estimate of $186,000 has been prepared (Appendix B). This cost has been amortized over a lifetime of 20 years at an interest rate of 8%. It is further estimated that the operation and maintenance of this structure would cost approximately $50,000/yr. This figure represents the normal 12% rule used by APWA to estimate O&M costs and an additional amount to account for the dredging immediately upstream of the structure that likely will be periodically required (70).

Thus, the annual cost of the control structure at the "Narrows" is:

$186,000 × 0.102 (Amortization Factor) + $50,000 = $69,300

The unit cost per kilogram of phosphorus removed is:

A. $\frac{\$69,300}{3,460} = \$20.03/\text{kg or about } \$20/\text{kg P removed}$

Empire Boulevard -- Assuming that the current embankment that supports Empire Boulevard would only require strengthening, a control structure similar to that at the "Narrows" would be required. However, in order to maintain the traffic flow along Empire Boulevard, a bridge over the control structure would also be required. As shown in Appendix B, the capital cost of the facilities is estimated at $2,000,000. Higher O&M costs than at the "Narrows" are anticipated because of the need to inspect and maintain the Empire Boulevard embankment. This cost is estimated at $120,000/yr. Thus, the annual total cost is estimated to be:

$\$2,000,000 \times 0.102 + 120,000 = \$324,000$

If this structure were used to control the entire wetlands area, the unit cost per kilogram of phosphorus removed would be:

B. $\frac{\$324,000}{5,280} = \$61.36/\text{kg or about } \$61/\text{kg P removed}$

If this structure were built at the same time that a structure at the "Narrows" was built, the unit cost per kilogram of phosphorus removed would be as follows:

C. $\frac{\$\ 69,300 + \$324,000}{5,920} = \frac{\$393,300}{5,920} = \$66.44/\text{kg or about } \$66/\text{kg P removed}$

If this structure were built after the capacity of the upper wetlands was exhausted, the cost, in 1982 dollars, would be:

D. $\frac{\$324,000}{3,840} = \$84.38/\text{kg or about } \$84/\text{kg P removed}$

From Table 32, it can be seen that the use of the upper wetlands provides the most cost-effective treatment. The total amount of phosphorus annually removed would likely be greater than the quantities indicated in Table 32 because processes other than sedimentation, as previously identified, would remove a portion of the dissolved fraction. Sedimentation involves only removal of a portion of the particulate fraction.

TABLE 32. COST-EFFECTIVENESS SUMMARY FOR UTILIZATION OF WETLANDS IMMEDIATELY UPSTREAM OF BAY

Alternative	Annual Removal (kg)	Annual Cost ($)	Annual Unit Cost ($/kg P removed)
A Upper wetlands (control structure at "Narrows")	3,460	69,300	20
B Upper and lower wetlands (control structure at Empire Blvd.)	5,280	324,000	61
C Upper and lower wetlands utilized simultaneously (one control structure at both the "Narrows" and at Empire Blvd.)	5,920	393,000	66
D Lower wetlands utilized (control structure at Empire Blvd.) after exhaustion of storage capacity in upper wet lands	3,840	324,000	84

Implementability--

Any of the four options for the use of the wetlands would require management and operational support from some form of governmental entity. There currently exists no agency with a clearly defined responsibility for management of such issues in the Irondequoit Bay watershed. The Monroe County Departments of Engineering and

Wastewater Management possess the size and talent to undertake such a program, but their current functions, as directed by the Irondequoit Bay Pure Waters District, do not include this type of activity, nor does the Charter of the Pure Waters District mandate this type of activity. Alternatively, the New York State Legislature has recently authorized the formation of special lake protection districts to provide the type of service needed for wetlands utilization. Institutional implementability is discussed in greater detail in Section 9.

Public Acceptability--

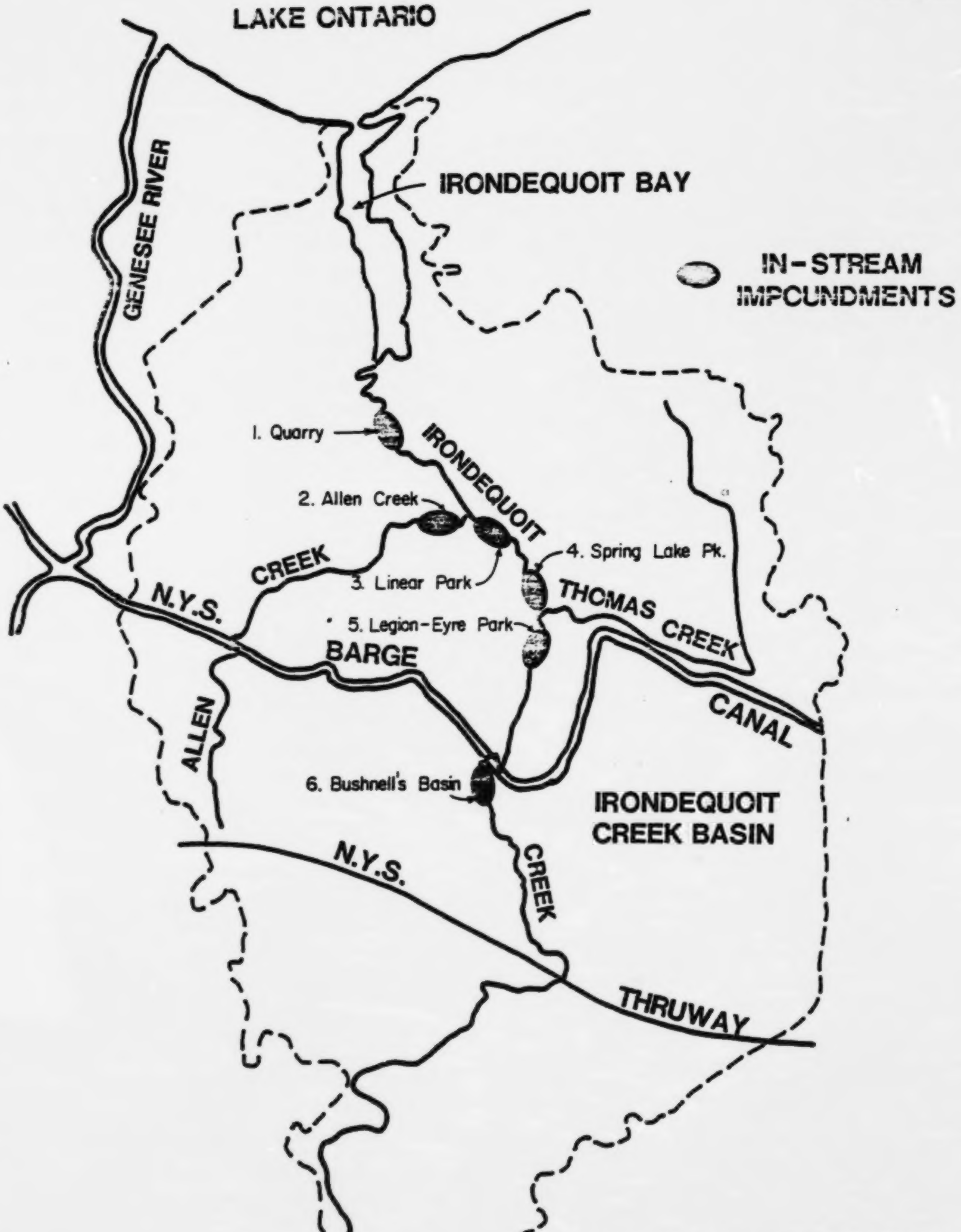
An assessment of public acceptability is contained in the responsiveness summary (Appendix F).

In-Stream Impoundments

Description--

As shown in Figure 14, the COE identified six locations along Irondequoit Creek where excess storm runoff flows could be retained. These facilities would be constructed such that normal dry-weather stream flows would pass through the impoundment without restriction. Storm flows, however, up to the capacity of the structure, would be retained and discharged slowly after downstream flowrates lessen. Flows in excess of basin capacity would also be passed without causing structural damage to the control structure and without inducing significant upstream flooding.

FIGURE 14


LAKE ONTARIO
IRONDEQUOIT BAY
IN-STREAM IMPOUNDMENTS
GENESEE RIVER
1. Quarry
IRONDEQUOIT
2. Allen Creek
3. Linear Park
4. Spring Lake Pk.
5. Legion-Eyre Park
CREEK
N.Y.S.
BARGE
CANAL
THOMAS CREEK
ALLEN
6. Bushnell's Basin
IRONDEQUOIT CREEK BASIN
CREEK
N.Y.S.
THRUWAY

IN-STREAM IMPOUNDMENTS

A preliminary evaluation of the six locations, based on factors other than available storage capacity, was made to determine if these impoundments were feasible from the standpoint of stormwater management. The results of this evaluation are shown below:

Site	Common Name	Feasibility	Storage Volume ($\times 10^6$ m^3)
1	Quarry	No	1.63
2	Allen Creek	Yes	0.53
3	Linear Park	No	0.53
4	Spring Lake Park	Yes	0.95
5	Legion-Eyre Park	No	0.73
6	Bushnell's Basin	Yes	0.95

Sites 1, 3 and 5 were immediately discarded for numerous reasons. The quarry is currently active, so that acquisition would be expensive. Furthermore, its stated capacity results from its depth and not on its surface area. Sedimentation is more effective when the basin has a large surface area/volume ratio. The Linear Park site simply does not have sufficient capacity to retain anticipated storm flows. The Legion-Eyre Park site has been so extensively developed that land acquisition would be expensive and unpopular.

Effectiveness--

The phosphorus removal mechanisms and calculations are similar to those for the wetlands. Phosphorus removals are calculated as follows:

Site	Storage ($\times 10^6 m^3$)	Drainage Area (ha)	Sediment Removal (%)	P Removed (kg/yr)
2	0.53	7260	61	2420
4	0.95	23850	46	2400
6	0.95	12960	61	2330
4+6	-	-	-	3650
2+4+6	-	-	-	6070

The second from the last line shows the result of constructing impoundments 4 and 6. The construction of site 6 reduces the sediment and phosphorus load reaching site 4. Thus, while the efficiency of site 4 increases, the quantity available for removal decreases. Since Allen Creek is tributary to Irondequoit Creek downstream from site 4, construction of site 2 has no effect on sites 4 and 6. Because of these factors, available storage, drainage areas, and sediment removal are not additive parameters. Therefore, their values are excluded from the table.

Costs--

The costs for each of the control structures are shown in Appendix B. These costs include land acquisition, dams, controls, and shoreline protection. Capital costs have been amortized in an analagous manner to the wetlands utilization costs. O&M costs are calculated again as 12% of the capital costs less land acquisition. Costs for the in-stream impoundments are as follows:

Site	Capital Cost ($)	O&M Cost ($/yr)	Total Annual Cost ($)	P Removed (kg/yr)	Unit Cost ($/kg P removed)
2	466,000	47,280	94,812	2420	39.18
4	635,000	30,000	94,770	2400	39.49
6	780,000	40,800	120,360	2330	51.66
4 + 6	1,415,000	70,800	215,300	3650	58.99
2+4+6	1,881,000	118,080	310,172	6070	51.10

From this analysis, it can be seen that the unit removal costs using in-stream impoundments are about the same as for the wetlands control options except for the use of the upper wetlands (control structure at the "Narrows").

Implementability--

The local implementability issues are the same as for the wetlands, that is, what governmental entity should have responsibility for these facilities. The same conclusions as formulated previously apply for the in-stream impoundments.

At the state and federal levels, an environmental review should be anticipated. However, the issues should be less difficult than with the wetlands. The impact on migratory fish will require the most extensive effort, but once again, no unsurmountable obstacles are likely to occur if the environmental review process is properly followed.

Public Acceptance--

The same discussion as set forth previously applies here. However, the matter of maintaining large ponded areas in suburban neighborhoods may be a concern to the public.

Erosion and Sediment Control

Description--

The practice of erosion control is a highly desirable method of reducing sediment runoff and therefore particulate phosphorus and other pollutants. This technology offers the further advantage that in developing areas, the construction costs can be passed on to the developer, thus eliminating a cost to government other than the review costs needed to assure conformance. Control measures to minimize erosion, however, could be put in place through the adoption of a number of town and/or village ordinances which meet both local needs specific to each municipality and which are also consistent with identified watershed water quality goals. An example of an ordinance is presented in Appendix C.

Erosion in developing areas occurs in two stages. During actual development when large areas of land are stripped of cover, sediment loss is great. During this period, control measures, such as detention ponds and green belts, can provide an effective means of reducing sediment loss. These control measures, however, would require a high degree of maintenance because of accumulated sediment. Once the developing area is complete and permanent ground cover has been restored, sediment loss becomes much less. These control measures, while still effective, remove less sediment because of the reduced loading. Also, O&M costs are correspondingly lower. Thus, the cost-effectiveness of these control measures must be evaluated in two stages, in active and in developed areas.

Effectiveness--

The CGR has reported that by 1990 approximately 1200 ha of additional lands in the drainage basin within Monroe County will be developed (78). Allowing for road construction and other public works projects, it is estimated that 160 ha/yr will be under active construction and subject to erosion. It has been reported that erosion for developing areas can result in the loss of 33600 kg sediment per hectare per year (79). As a part of the IBNURP monitoring program, the MCHD conducted limited sampling and analyses at an active construction site in the Town of Pittsford, known as the Versailles site. Erosion controls had been identified in the design review plans for this residential development. Inspection and enforcement of these control measures, however, were not realized.

Preliminary results of the Versailles data showed that the phosphorus concentration of sediment was about 180 mg P/kg of suspended solids (SS). The total phosphorus load resulting from erosion can, therefore, be calculated according to the following equation:

$$\text{Phosphorus lost} = 33600\ \text{kg sediment/ha/yr} \times 160\ \text{ha} \times 180\ \text{mg P/kg sediment} \times \frac{\text{kg}}{10^6\ \text{mg}} = 970\ \text{kg P/yr}$$

This value represents about 7 percent of the total phosphorus load reaching Blossom Road. It is estimated, however, that a substantially greater phosphorus load can be attributed to erosion because this calculation pertains only to developing areas. It does not take into account the remainder of the watershed nor does it include stream bank erosion. For determining the cost-effectiveness of erosion controls, it was estimated that approximately 4800 kg/yr of phosphorus can be attributed to erosion or about one-third of the total annual load.

As will be discussed later, a comprehensive drainage and erosion control ordinance would be difficult to implement and enforce. It is, therefore, assumed that the maximum effectiveness of various erosion control measures would result in a 25-50% removal of phosphorus even though the reported efficiency of properly designed detention basins can exceed 60% (70). Thus, in Monroe County, 1200-2400 kg/yr of phosphorus could be retained for as long as development continued at the current rate.

It is somewhat more difficult to calculate the effectiveness of control measures for fully developed areas. Based on the runoff modeling described in Section 7, the average phosphorus load to the bay from the basin is 0.39 kg/ha/yr. By 1990, an additional 1200 ha will have been developed. Since this area could potentially have erosion control, it would be possible to control 470 kg/yr of phosphorus. For the same reasons given above, it is assumed that this program would also be 25-50% effective, resulting in an actual reduction of 120-240 kg/yr.

Costs--

The costs of constructing erosion controls are reported to vary from $750-12400/ha (70). In typical developments, this cost is borne by the developer and passed on to the purchaser of the property. The facilities are turned over to the appropriate governmental agency after they have been in operation for a period of time, usually one year. Thus, there is no direct cost to the town, village or county government. The cost of enforcement would represent an indirect cost which would could amount $49,600/yr based on an estimated cost of $310/ha (70). Using these numbers, the unit would be $28/kg P removed, assuming an average of 1800 kg/yr of phosphorus is removed.

The capital cost of these facilities was based on a figure of $3200/ha. In any one year, the total cost would be $512,000. It is reasonable to assume that the developer would spread this cost over several years. Using the same amortization factor as before, the annual cost of these facilities would be $52,200. However, the facilities would remove 1800 kg P for the life of the active construction after which time the removal would likely be less than ten percent of this figure. Thus, the cost per kilogram of phosphorus removed is best represented by dividing the total cost by the quantity of phosphorus removed. It is conservatively estimated that the sites are active for two years and, therefore, control 3600 kg P. The unit cost then becomes $142/kg P removed. It is important to note that this cost would not be borne by government, but by the ultimate users and benefactors of the property. Therefore, the $142/kg P figure was not used for comparative purposes, but rather, only the enforcement costs were considered, i.e., $28/kg P removed.

Once the area is developed, the O&M costs would be carried by government. O&M costs were estimated to be 12% of the original construction cost. For the 1200 ha of drainage basin within Monroe County to be developed, total O&M costs would be $460,800. The decreased low sediment loading rate from developed areas indicates that this cost would be somewhat lower and was estimated to be $250,000. The unit cost is then $1390/kg P removed/yr.

This analysis shows that the control of phosphorus in developing areas is cost-effective only during the active construction period and, then, only if the construction costs are passed on to the user. Otherwise it is more effective to control this source of phosphorus through in-stream impoundments and the use of the wetlands. Although difficult to estimate, phosphorus controlled through erosion controls would lead to less sediment, thereby reducing the frequency at which sediment would have to be removed from other detention basin facilities (in-stream impoundments and wetlands). This would decrease their O&M costs.

Implementability--

Traditionally, the control of drainage and erosion has been a function of town and village governments. Adoption of a uniform ordinance encompassing the entire watershed would likely be ineffective because it would not adequately address conditions specific to each municipality. It should be noted that the need for adopting local erosion control ordinances has been identified within the Irondequoit Bay watershed in a recent study conducted by Monroe County.

It was not the intent of this study to develop a model ordinance. Monroe County and/or each municipality should develop an ordinance based on local and overall watershed needs which is consistent with established guidelines, such as those provided by the Soil Conservation Service (67). The best method of actual ordinance implementation should be studied as part of a water quality management plan.

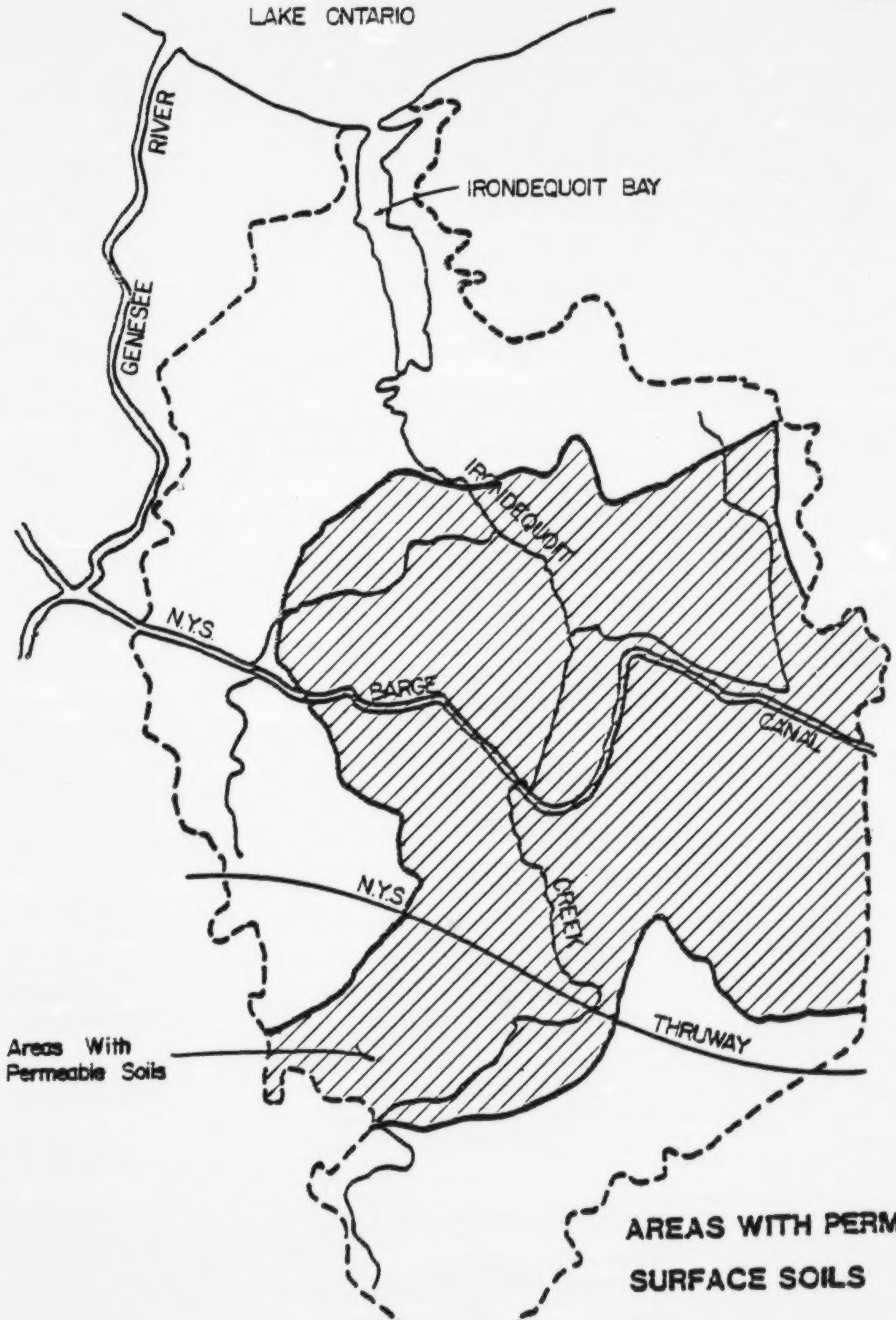
Public Acceptance--

This issue is discussed in Sections 9 and 10 and also in the responsiveness summary presented in Appendix F.

Stormwater Infiltration

The discharge of stormwater to the upper soil layers can be a control measure that involves reducing all pollutant loadings by 100%. Consideration, however, must be given to the potential contamination of aquifers that are used as a source of drinking water. Since the deeper aquifers in the Irondequoit watersheds are used for the purpose, discharge will be evaluated only where the surficial soils are of adequate permeability. In this way, stormwater would remain in the upper soil layer. Figure 15 shows the areas within the Irondequoit Bay watershed with surficial soils of high permeability. It is desirable, however, that these discharges be pretreated to remove as many pollutants as possible. Swirl concentrators are effective, low cost devices for particulate removal. This process generates a concentrated waste

FIGURE 15


LAKE ONTARIO
GENESEE RIVER
IRONDEQUOIT BAY
IRONDEQUOIT
CREEK
N.Y.S.
BARGE
CANAL
N.Y.S.
THRUWAY
Areas With Permeable Soils

AREAS WITH PERMEABLE SURFACE SOILS

stream which must be considered. The most cost-effective method for disposal of this waste stream is discharge to an existing wastewater conveyance system. Obviously, this discharge is possible only in sewered areas. These areas are identified in Figure 16.

In order to discharge to the soil, some form of stream diversion structure would be required. More importantly, some form of inlet structure, such as a retention pond or seepage pit, would also be required. As a practical consideration, it is assumed that each inlet structure could accept stormwater flow from a maximum area of 20 ha.

Effectiveness--

Table 33 indicates the quantity of phosphorus that could be controlled by stormwater infiltration.

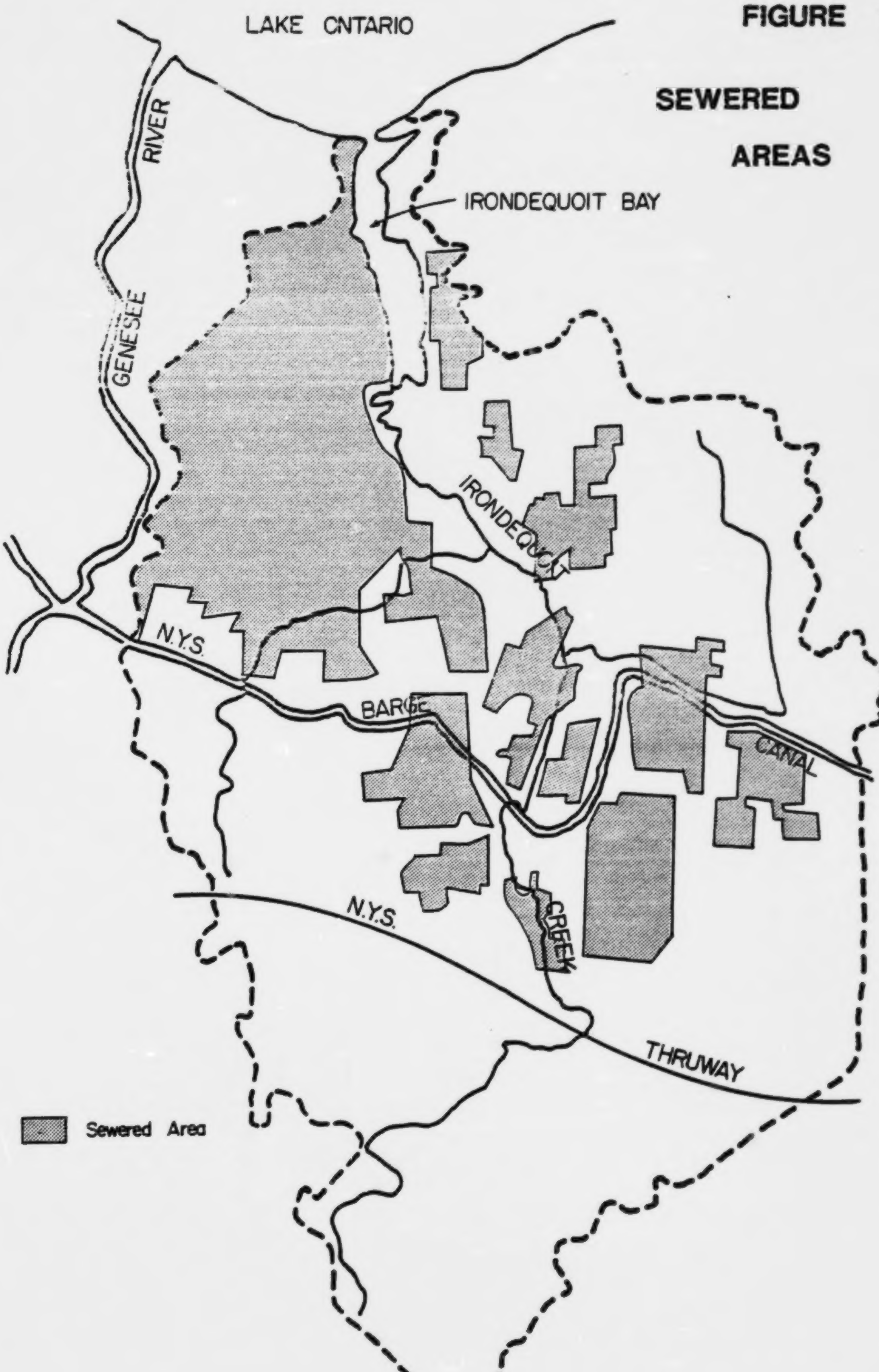
TABLE 33. EFFECTIVENESS OF STORMWATER INFILTRATION

Subbasin	Size (ha)	Average P Loading (kg/yr)	Area with Permeable Soils (%)	Phosphorus Removed (kg/yr)
Thornell	11508	5090	40	2040
Thomas Creek	7387	1340	90	1210
Allen Creek	7802	5440	60	3260
Central	10368	2460	90	2210
			Total	8720

The last column reveals that a total of 8720 kg/yr of phosphorus could theoretically be removed. Assuming that only 50% of the storm flows could feasibly be diverted, a total of 4360 kg P/yr could be removed if stormwater runoff throughout the basin were intercepted by these inlet structures.

FIGURE 15

SEWERED AREAS


LAKE ONTARIO
GENESEE RIVER
IRONDEQUOIT BAY
IRONDEQUOIT CREEK
N.Y.S. BARGE CANAL
N.Y.S. THRUWAY
▨ Sewered Area

Cost--

Table 34 shows the basis for calculating the number of inlet structures and swirl concentrators.

TABLE 34. COSTS FOR STORMWATER INFILTRATION

Subbasin	Size (ha)	Area with Permeable Soils (%)	Number of Wells (1/20 ha)	Sewered Areas (%)	Number of Swirl Units
Thornell	11508	40	230	0	0
Thomas Creek	7387	90	332	10	33
Allen Creek	7802	60	234	90	211
Central	10368	90	467	83	388
		Totals	1263		632

The capital costs for the inlet structures and swirl concentrators, sized for runoff from 20 ha for a 5 yr storm, are estimated at $10,000 and $12,000, respectively. The O&M costs are estimated at $1,200 and $1,000, respectively. The lower O&M cost is one of the attractive features of swirl concentrators (59). Thus, annual costs are as follows (based on a similar amortization factor, as previously identified):

Without swirl units	$2,804,000
With swirl units	$4,210,000

The unit cost for phosphorus removal is:

Without swirl units	$643/kg P removed
With swirl units	$966/kg P removed

These figures clearly show that stormwater infiltration is not a cost-effective method of reducing phosphorus loads when compared to wetland utilization, in-stream impoundments and erosion/runoff controls. However, this analysis assumes a uniform loading rate, an assumption which is not true, as seen from the IBNURP site data. Obviously, the higher the loading rate, the more cost-effective this technology becomes.

Figure 17 shows the relationship of $/kg P removed to loading rate in kg P/ha/yr. As illustrated, the cost of stormwater infiltration becomes increasingly competitive with other technologies (except the use of the upper wetlands) when the loading rate becomes consistently greater than 4 kg/ha/yr. This rate is observed only in dense urban or commercial areas, such as the East Rochester and Southgate sites, as can be seen from the data presented in Tables 11 and 12.

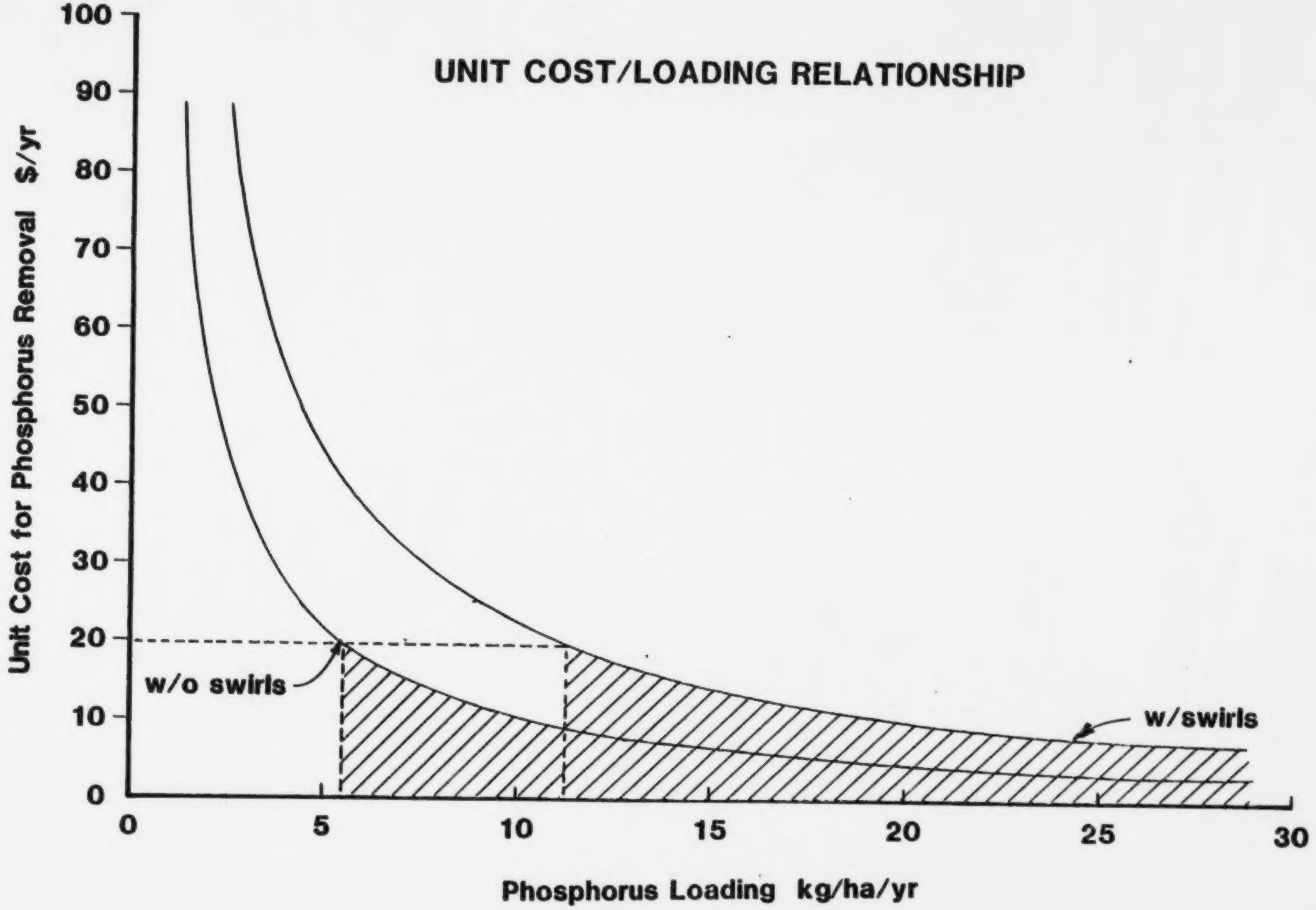
Implementability--

A comprehensive stormwater infiltration program would require the direction of some form of county or basinwide agency or regulation, as mentioned earlier in this report. However, the implementation of a program in East Rochester could conceivably be directed by the village. The matter of funding is a separate issue. It is unlikely that the village would be willing to fund even a reduced program. A wider base, over which to spread the cost, would likely be required.

A permit, issued by the NYSDEC, would be required to discharge stormwater to groundwater. In order to obtain this permit, it would be necessary to demonstrate that the discharge would not lead to contravention of already established groundwater standards. Because of the observed levels of heavy metals, especially in the more highly concentrated first-flush or initial flow, some form of treatment would likely be required. Since a large fraction of heavy metals are associated with particulates, some form of particulate control, such as swirl concentrators, would be effective for this purpose.

Based on this analysis, a comprehensive plan involving the widespread use of stormwater infiltration systems is not economically feasible. Applicable of such measures, however, in developing areas within Monroe County could be effective. Since small scale (site-specific) stormwater

FIGURE 17



UNIT COST/LOADING RELATIONSHIP

infiltration systems have been demonstrated to be effective in the county, this control technology should be encouraged and receive full consideration during the development design review process.

Public Acceptance--

Although this control measure was not expected to create public controversy, several individuals and groups expressed their concern for protecting the groundwater resources of Monroe County at the public hearing. Their questions and answers are presented in the responsiveness summary, which is included as Appendix F. It is for these reasons that this report has stated that direct injection of stormwater into usable underground aquifers is not desirable or recommended.

RECEIVING WATER QUALITY IMPACTS

The purpose of this section is to assemble the various control options into a cost-effective management plan for controlling stormwater pollution from urban and suburban areas. While the relative effectiveness of the various options can be expressed in terms of annual cost per unit weight of phosphorus, it is necessary to establish an overall goal for phosphorus control. The ultimate resolution of this particular issue must await the completion of the Clean Lakes and the Agricultural Runoff Studies in order to compare the effectiveness and synergystic effects of controlling both the internal and external phosphorus loads. However, it is possible at the present to estimate the maximum reduction in epilimnion phosphorus that could be achieved by controlling external loads through various basinwide control measures.

As discussed in Sections 4 and 7, it is recognized that, although it is not possible to realistically separate the effects of internal and external loads, they had to be treated as independent in order to predict water quality improvement in response to reduced stormwater loadings. Figure 18 shows the range of values that could be anticipated under various reductions in external loads. The intersection of the lines representing the current (summer) epilimnion phosphorus concentration (100 $\mu g/l$) and the current external loading (39 kg/day), define the existing (1981) situation in the bay. As discussed earlier, the average water column phosphorus concentration was the selected indicator of water quality. The water quality model indicated that the relationship between external loads and water column phosphorus concentrations can be represented by parallel lines, each representing a given internal load. The only way in which to rationally assess the effectiveness of various basinwide control measures, however, is to predict water column phosphorus concentrations under the condition of negligible internal loading. It has been shown that: 1) internal loads decrease with a reduction in external loads, and 2) bay intervention techniques (such as sealing the bottom sediments) can quickly eliminate phosphorus released from bottom muds. Thus, it is logical to assume negligible internal loading and then predict changes in water quality with changes in external loadings.

It is difficult to quantitatively relate phosphorus to potential usage of the bay. The following table shows the general relationship of lake classification to epilimnion phosphorus (27):

Category	Phosphorus (μg/l)
Ultra-oligotrophic	<5
Oligo-mesotrophic	5 - 10
Meso-eutrophic	10 - 30
Eutrophic	30 - 100
Hypereutrophic	>100

This table, similar to Table 1 presented in Section 4, simply expands the number of categories based on finer degrees of eutrophication. To achieve an average water column phosphorus concentration of 20-30 μg/l, the goal as identified earlier, the present external loading rate must be reduced from 39 kg/day to about 14 kg/day. Since this analysis was conducted under the condition of negligible internal loading, this decreased external loading would maintain the bay in an improved trophic state (meso-eutrophic) once the internal load is brought under control. From Table 35, it is seen that the most cost-effective control measure to reduce the external loading rate to 14 kg/day is the use of the upper wetlands, in-stream impoundments, and erosion/runoff controls. From

Figure 18, by reducing the external (stormwater) phosphorus loading to this level, the average epilimnion phosphorus concentration would be reduced to approximately 20 μg/l, the desired level.

It is obvious that all of the recommended control measures deal with the removal of particulate phosphorus. It is important to note, however, that algae in the bay are also dependent on soluble forms of phosphorus. Although the cost-effectiveness analyses described in this report reflect only particulate phosphorus removal, use of the wetlands would actually involve the removal of a fraction of the soluble portiondue to biological uptake within the resident plant community. Thus, implementation of the use of the wetlands would likely result in somewhat greater improvement in bay water quality than that shown in Figure 18 because of actual greater amounts of all forms of phosphorus being removed.

To improve the bay to a greater degree, further reductions in phosphorus loadings are needed and the results of this study can be used to rank the control measures on a preliminary basis. To provide additional needed data to make such projections and to assess the improvement in bay water quality following implementation of any control measures, it is recommended that the current monitoring program be continued to obtain these data. At a minimum, the following data are necessary:

Sampling Locations

Blossom Road, "Narrows"
Allen Creek, Thomas Creek, Thornell Road
3-5 sites at surface, mid-depth and bottom of Irondequoit Bay

Parameters To Be Measured

Rainfall
Stream flowrates
Total phosphorus
Particulate phosphorus
Total suspended solids
Other nutrients, heavy metals and toxicants, as desired

TABLE 35. EFFECTIVENESS SUMMARY FOR SELECTED CONTROL MEASURES

Control Measure	Phosphorus Removed (kg)		Adjusted Bay Loading (kg)		Epilimnion P (µg/l) Reduction		Annual Cost ($)	Unit Cost ($/kg P removed)
	Annual	Daily	Annual	Daily	Change	New Level		
1. Upper Wetlands (Control structure at the "Narrows")	3460	9.5	10,880	29.8	8	32	69,300	20
2. Lower Wetlands (After exhaustion of Upper Wetlands)	3840	10.5	10,500	28.7	9	31	324,000	84
3. Upper and Lower Wetlands (Control structure at Empire Blvd.)	5280	14.5	9,060	24.8	12	28	324,000	61
4. Upper and Lower Wetlands (Control structures at "Narrows" and Empire Blvd.)	5920	16.2	8,420	23.1	14	26	393,000	66
5. Reservoir 2	2420	6.6	11,920	32.6	6	34	94,812	39
6. Reservoir 4	2400	6.6	11,940	32.7	6	34	94,770	39
7. Reservoir 6	2330	6.4	12,010	32.9	5	35	120,360	52
8. Reservoirs 4 and 6	3650	10.0	10,690	29.3	9	31	215,300	59
9. Reservoirs, 2, 4, and 6	6070	16.6	8,270	22.6	14	26	310,172	51
10. Erosion Controls (Active development)	1800	4.9	12,540	34.3	4	36	49,600	28
11. Stormwater Infiltration For Basinwide Control (with swirl concentrators)	4360	11.9	9,980	27.3	10	30	4,210,000	966
12. Items 1 and 9	7340	20.1	7,000	19.2	16	23	379,472	52
13. Items 1, 9, and 10	9140	25.0	5,200	14.2	20	19	429,072	47
14. Items 1 and 10	5260	14.4	9,080	24.9	12	28	118,900	23

WATER QUALITY RESPONSE CURVES

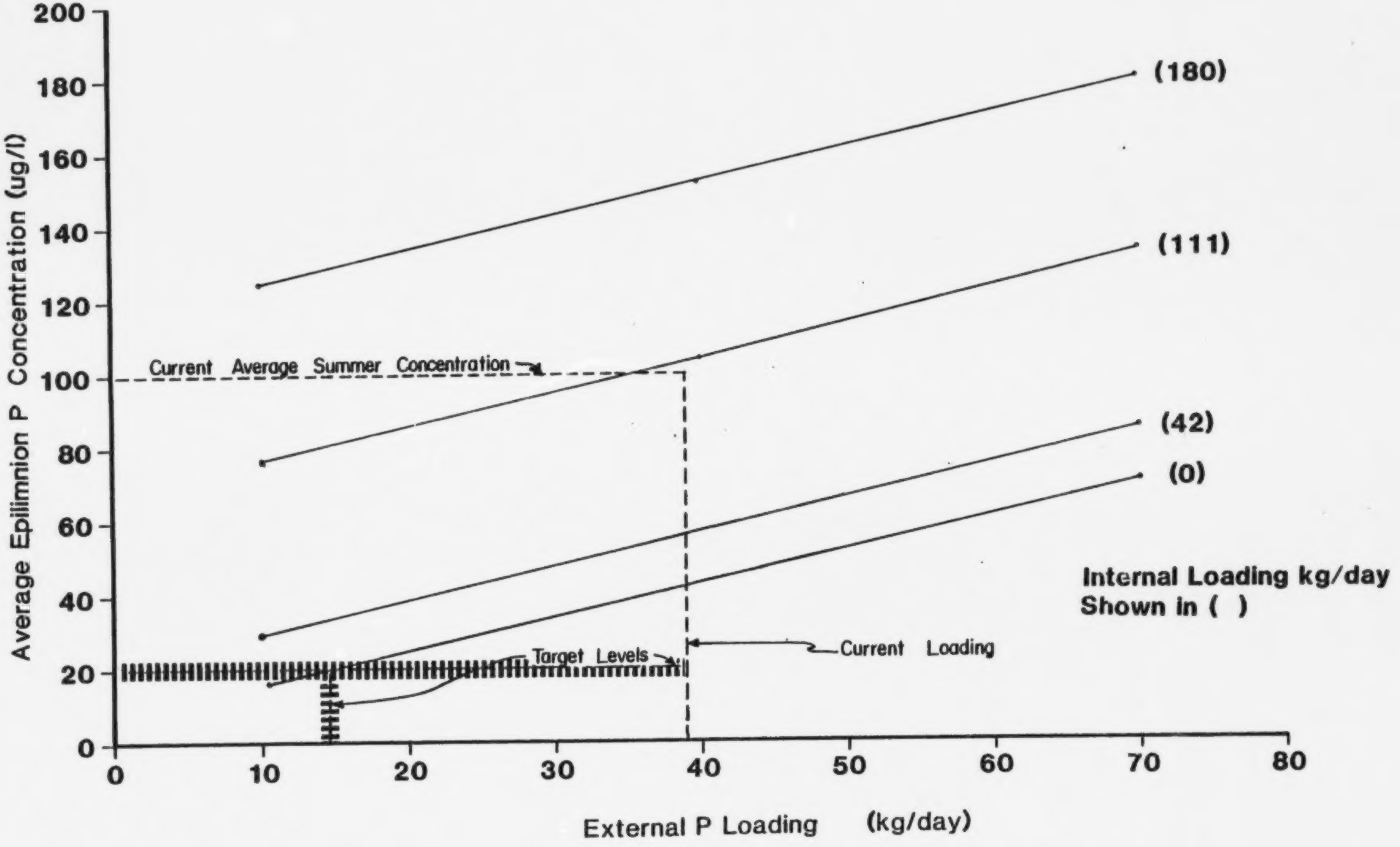


FIGURE 18

The frequency of sampling should be adequate to characterize the loadings and bay mass transfer rates. At a minimum, monthly samples during dry weather (including winter) and hourly samples during typical wet-weather events should be collected. In addition, provisions should be made to intensively sample at least three storm events with particular emphasis on spring runoff.

SECTION 9
INSTITUTIONAL CONSIDERATIONS

INTRODUCTION

This section is taken from a report prepared by the Center for Governmental Research, Inc., in cooperation with all members of the Technical Advisory Team and the Irondequoit Basin Subcommittee. This report is reproduced in its entirety as Appendix D. It presents potential administrative arrangements for the management of stormwater and other nonpoint source pollution in Monroe County. As part of the IBNURP effort, organizational alternatives for dealing specifically with the effects of urban runoff on the water quality of Irondequoit Bay are emphasized. At the same time, the report attempts as much as possible to anticipate the institutional arrangements which may be required to implement recommendations under the forthcoming companion studies, including the Clean Lakes Program and the Agricultural Nonpoint Source Study. These and other studies will be used as a basis to develop a comprehensive water quality management plan for the Irondequoit basin. It is anticipated that this plan will be completed in 1984. The analysis of administrative arrangements assumes a two-tiered aspect:

- In the short term, what organizational and financial arrangements are needed to implement the recommendations identified in Section 2 of this report.
- In the long term, how should Monroe County as a whole organize and provide financing for strategies to achieve goals related to nonpoint source pollution?

SHORT TERM CONSIDERATIONS

In the short term, certain immediate responses to the IBNURP are necessary. In most cases, these responses involve simply an affirmation on the part of a department that its involvement in a given function will continue. In other cases, a department may be encouraged to assume a function which is a logical extension of its current functions, at least in the short term. The following table presents those departments that would be likely to assume the function listed for each of the recommendations identified in Section 2.

Recommendation	Function	Department/Agency
1, 3	Surveying, Research Projects in Wetlands and Specific Urban Areas Monitoring, Sampling	Monroe County Pure Waters Agency, Irondequoit Bay Pure Waters District, Departments of Engineering, Health United States Geological Survey
4	Technical Assistance to Towns, Training in Erosion Control, Ordinance Formation	Monroe County Department of Planning
5	Monitoring, Sampling	Monroe County Health Department
6	Stormwater Infiltration	Monroe County Department of Engineering United States Geological Survey
7	Public Participation/ Information	Monroe County Department of Planning, Water Quality Management Committee

The county legislature is encouraged to provide adequate funding to these departments, where applicable to continue and/or complete ongoing projects.

Recommendation Number 2 (see Section 2) calls for the establishment of water quality objectives for Irondequoit Bay regarding the concentrations of certain pollutants. The function of overall policy development for water quality (and particularly for nonpoint source pollution) and the approval process for such policy in the county, has not yet been assigned by the county legislature. Unless and until the legislature formally designates an official or agency to assume policy direction, it alone should establish such a policy. Recommendations for the development of policy and an approval process are presently under study by CGR. The technical nature of water quality standards and management suggests that the policy direction function, exclusive of final budget approval, be delegated by the legislature.

In the short term, it is apparent that the decentralization of functions will continue. No single administrative unit meets all the criteria identified in Appendix D and agreed upon to be necessary to manage nonpoint source pollution.

LONG TERM CONSIDERATIONS

Other functions which may not be necessary in the short term to implement specific IBNURP recommendations will certainly be required to develop a long range strategy to achieve water quality goals throughout Monroe County. These functions include:

- Planning - including recognizing the need for and the coordination of all county water quality projects related to nonpoint source pollution to insure their compatibility; to identify potential sources of funding for future projects; to provide training and technical assistance to interested parties.

- Intergovernmental coordination - through providing a forum for the free exchange of ideas and concerns among participating agencies and governments; to encourage these participants to work toward the common goal of controlling nonpoint source pollution.

- Capital construction and contract administration for projects of non-recurring nature; to alleviate major causes of nonpoint source pollution over the long term.

- Maintenance and operation of facilities on an ongoing basis.

The CGR analysis of potential institutional arrangements to perform these functions is presented in Appendix D. The findings of this analysis are summarized in the following paragraphs.

In the long run, and after considerable public discussion, it is assumed that a configuration of new and/or existing agencies could most effectively perform these functions. This multi-component strategy would presumably be a variation on the status quo arrangement to the extent that it would include departments, agencies and governmental levels currently involved in nonpoint source pollution. The questions presented in Appendix D could be used to formulate such a strategy.

The most important steps in such a process would be to achieve formal agreement as to what agency or department would handle each function, to see that all functions are assigned with principal accountability to one agency, and to ensure that stable funding mechanisms are provided. In Monroe County, examples of issues to be dealt with include the specific assignment of functions which currently are not clearly designated (such as overall direction and intergovernmental coordination) to an independent water quality management agency and the feasibility of organizing a lake protection district for the Irondequoit Basin watershed.

It is apparent that no general agreement exists on the nonpoint source water quality management role of currently involved governmental entities in the county. In the interim, therefore, before the publication of a water quality management plan, representatives of all agencies actively involved with nonpoint source management in the county should develop a unified planning work program.

The purpose of such a plan is to accurately represent the current distribution of water quality management functions. Building on the outline in this report, such an analysis should also provide specific definitions of each discrete function performed. This work plan could then be used to formulate long run recommendations for the final report on water quality management.

Based on the information presented in Appendix D and on a review of the solutions to similar problems in the past, the resolution of these issues does not appear to pose an insurmountable obstacle for Monroe County. Indeed, the Monroe County Pure Waters Agency faced and solved an equally or more difficult problem with respect to the management of point source pollution. The result is one of the nation's most comprehensive and successful wastewater management programs. The application of the same resources which led to the creation of the Pure Waters Agency could also lead to the successful resolution of nonpoint source water quality management issues in Monroe County.

SECTION 10
PUBLIC PARTICIPATION PROGRAM

INTRODUCTION

The purpose of the public participation program was to involve and inform citizens of the efforts undertaken as part of the Irondequoit Bay Nationwide Urban Runoff Program (IBNURP).

The public participation program was developed by the Monroe County Department of Planning in accordance with federal guidelines for a full public participation program. Staffing responsibility for the public participation program lies with the Monroe County Department of Planning through an agreement with the Irondequoit Bay Pure Waters District. The public participation workplan, as amended during the project to reflect changes in the timing of the public participation program because of project delays and because of improved methods of public communication, is shown in Appendix E.

ADVISORY GROUP

Several methods of involving citizens have taken place with the focal point of the public participation program being the advisory group known as the Irondequoit Basin Subcommittee (IBS) of the Monroe County Water Quality Management (WQM) Committee. This committee was organized in February of 1980 to serve as the principal advisory group to a number of county water quality and wastewater management studies. To carry out its responsibilities, the committee formed several subcommittees, each related to a particular water quality study area. The Irondequoit Basin Subcommittee (IBS) was formed to advise the public on IBNURP and two other projects taking place in the Irondequoit basin. Members of the subcommittee are made up of interested members of the WQM Committee and other members solicited from local governments within the watershed. Current membership of both the IBS and WQM Committee is shown in Appendix E.

The Irondequoit Basin Subcommittee first met on May 13, 1980 at which time, Robert Jonas, a citizen member of the Water Quality Management Committee was elected as chairperson of the subcommittee. The subcommittee has met often to hear progress reports from the study staff, to review plans and findings, and to make recommendations. Subcommittee members have been instrumental in helping the IBNURP project staff develop the public participation workplan and amendments, a mailing list, a brochure, and in setting the agenda for two public information meetings and the final public hearing. The subcommittee has been involved in all public participation activities.

The Irondequoit Basin Subcommittee has had a substantial role in the review of the final NURP report. The subcommittee began review of a preliminary draft of the final report in early November 1982. After initial comments, the subcommittee set a date for a public hearing and the official draft IBNURP report was printed. The subcommittee members reviewed this draft and summarized their comments at the January 25th public hearing. The subcommittee met in February and March of 1983 to consider the public comments regarding the report and to make recommendations on what should be included in this final report. The subcommittee completed review of this report in April, 1983.

PUBLIC INFORMATION MEETINGS

Two public information meetings have been held. The first meeting in November of 1980 centered around a slide show explaining the purpose of the project and the problems associated with urban runoff. Seventy people were in attendance at that meeting. A responsiveness summary was prepared which summarized the questions and answers generated by the information given (80). Publicity which preceded this meeting included a mailing sent to all individuals on the mailing list, a press release, public service announcements, newspaper advertisements, a poster, a post card sent to all persons on the mailing list as a reminder, and newspaper announcements.

The second public information meeting was held October 28, 1982 to update individuals on the progress of the study by explaining preliminary data results. Publicity which preceded this information meeting consisted of a legal notice printed 45 days in advance of the meeting, a post card sent to the entire mailing list 45 days in advance of the meeting, a large poster distributed to public places, an agenda sent to the entire mailing list, a public service announcement, calendar listing, news release, a follow-up reminder post card, and newspaper advertisements. Only data collected in 1980 were presented at this meeting because the final 1981 data reduction had not been completed. At the meeting, background information was given on the Irondequoit Bay basin, the procedures and purposes of the sampling program, 1980 test results, the kind of testing done in 1981, and the proposed steps in finalizing the project. Response from the attendees was good with over 30 comments and questions received. A responsiveness summary was prepared and sent to the entire mailing list (81).

PUBLIC HEARING

A public hearing to solicit comments regarding the draft IBNURP report was held on January 25, 1983. Copies of the official draft final report were made available to the public for review at all town and village halls in the watershed and at seven libraries and the Monroe County Department of Planning on December 23, 1982. People were notified of the availability of the report and of the public hearing date 45 days in advance of the hearing through a legal notice in three newspapers and through a direct mailing to those individuals on the mailing list. Further direct notification was done by a newsletter sent out January 4th, and a post card reminder on January 14th. In addition, a press release prompted several newspaper articles announcing the availability of the document and notification of the upcoming hearing date. Advertisements in newspapers were also used.

One hundred twenty-four people attended the public hearing which outlined the background of the IBNURP project and the recommendations of the draft final report. Ten individuals spoke at the public hearing.

The hearing record was left open ten days after the meeting during which time three written responses were received. A summary of the public hearing presentation, public comments, and responses is shown in Appendix F.

MEDIA INTEREST

Attention by the local media to this project has been good. Most publicity was a result of public meetings and the public hearing. Efforts by the public participation staff to attract media interest to these meetings included press releases, public service announcements, calendar listings, telephone contacts, and a press briefing. As a result of information made available to the press, over 30 newspaper articles appeared over the course of the project. In addition, eight radio interviews and five television news stories were done.

PUBLIC FORUMS

In order to reach more people, especially local officials, a slide show was taken around to the towns within the basin to explain the project and allow for a forum for considering local concerns and questions. Such forums were held in the Towns of Penfield, Brighton, Perinton, Pittsford, Irondequoit, and Webster, in the Villages of East Rochester and Fairport, and in the City of Rochester. In most cases, all local officials were invited and the public was advised through posters placed at local public places, and by mailings sent to those on our mailing list from those localities. A slide show explaining the project was used for these forums.

In addition to the public forums to involve town and village officials, the slide show was used to inform other citizen groups. During the fall of 1981 and the spring of 1982 public participation staff notified organizations of the availability of the slide show and presentations were made to several recreational groups. Those meetings were well received.

DISPLAYS

Two display boards were made to advertise the public forum in the municipal buildings where meetings were to take place. These display boards were later used at other locations to attract people and to obtain information about the IBNURP project. A display was set up for a week at the Monroe County Fair where people could pick up brochures, sign up to be on the mailing list, and see an aerial photo of the area included in the Irondequoit Bay watershed. The display was also used at an Information Fair at a shopping mall, and at a garden club convention held in the Rochester area.

INFORMATION CENTERS

The Monroe County Department of Planning has added to its library a collection of documents and background materials pertaining to the IBNURP study and other water quality studies in the Irondequoit Basin. In addition to this main depository, notebooks of information on the IBNURP and other Irondequoit basin studies have been distributed to municipal clerks in the watershed to be available to the public. These notebooks have been updated once since their completion in the fall of 1981. The information centers include minutes of Irondequoit Basin Subcommittee meetings, responsiveness summaries, and background information on the IBNURP project as well as other projects in the basin. The information centers will be updated again when the final IBNURP report is released.

MAILING LIST

A mailing list was started at the beginning of the project to include people living in the complete basin area. Approximately 650 individuals were on the mailing list at the beginning of the project. The present mailing list consists of over 950 individuals resulting from people requesting to be put on the mailing list.

PUBLICATIONS

Two major efforts have been made in distributing publications to inform the public about the IBNURP project. A brochure, shown in Appendix E, was completed in April of 1981 and distributed to public places within the watershed to notify people of the project.

A newsletter entitled "Irondequoit Basin Water Line" is being published to update people on the mailing list about the NURP project and other projects in the basin. The first issue was sent to 826 people in June of 1982 and was placed in libraries in the basin and in the Monroe County Office Building. A second issue outlining recommendations of the draft IBNURP report and announcing the hearing was sent in January 1983. Copies of the publication were also made available to the public through the distribution to local libraries.

The Monroe County Department of Planning publication "Overview" has served as another carrier of information to Monroe County people on the progress of the IBNURP project. Articles pertaining to the Nationwide Urban Runoff Program have appeared seven times since early 1980. The "Overview" publication is sent to 2,000 people approximately every two months.

PUBLIC PARTICIPATION EFFECTIVENESS

If the goal of the public participation program has been to involve the public throughout the NURP project, a number of measures of program effectiveness can be identified:

- extent of public understanding and support for the project
- quality and sophistication of public debate on relevant project issues
- quality and disposition of recommendations made to the grantee from the advisory group and the general public regarding project issues.

Although these indicators are difficult to quantify, the following indicators show that the public participation program has in fact been effective in reaching its goal:

1. There have been numerous and different kinds of public meetings and attendance at each has been good.
2. Comments made at the public meetings have indicated that there is widespread support and understanding of the project.
3. The final public hearing and final deliberations of the advisory group indicate understanding and general support for the project.
4. There is support from the towns and villages in the basin regarding the project recommendations.
5. Media response to the development and completion of the project has been frequent and supportive.
6. The mailing list was continuously expanded throughout the course of the project indicating increased public interest.
7. All levels of government were involved in the public participation program throughout the project.
8. The advisory group's involvement in the project was substantial as demonstrated by recommendations which were accepted by the grantee.
9. The public participation program resulted in the raising of a number of issues which were not directly related to the project but which need further public debate and eventual resolution. Such issues include groundwater management, intermunicipal approach to stormwater/urban runoff management, evaluation of erosion control administrative procedures, and role of Monroe County in water quality management planning.
10. The program created public understanding and support for the need for comprehensive water quality management in the basin so that implementation of recommended control measures will occur.

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GLOSSARY

ALGAE -	Simplest green plants having neither root, stem, not leaves; those in fresh water are usually microscopic in size.
ALGAL BLOOM -	Very rapid growth of algae with formation of large concentration which sometimes form floating mats or distinct coloration of the water
AQUATIC PLANTS -	Plants that grow in water. Some aquatic plants are rooted, some are free floating
BEST MANAGEMENT PRACTICES -	Measures to reduce stormwater pollutant loadings that focus on the source and collection system management. These measures are generally non-structural in nature.
CHLOROPHYLL A -	The primary photosynthetic pigment of all photosynthetic oxygen-evolving organisms that is present in all algae.
COMBINED SEWER -	A sewer that carries sanitary domestic wastes, industrial wastes, and surface runoff.
COMBINED SEWER OVERFLOW -	Discharge of a combined sewer system to receiving waters.
CULTURAL EUTROPHICATION -	The acceleration by human activities of the natural aging process in a lake.
DETENTION -	Temporary storage of surface runoff - either on, below or above the ground surface - accompanied by controlled release of the stored water.
DETENTION BASIN -	A stormwater detention facility, natural or artificial, which normally drains completely between storm events.
DETENTION POND -	A similar facility as the detention basin except that a fixed minimum water elevation between storm events is maintained. The water elevation may also lower between runoff events because of infiltration or evaporation.
EFFLUENT -	Treated or untreated wastewater that flows from sewers, treatment plants, or industrial plants.

EPILIMNION -	Upper warm circulating water layer in a stratified lake
EROSION -	Process by which soils are loosened and transported from one place to another.
EUTROPHIC -	Waters with excessive quantities of nutrients resulting in high levels of organic production.
EUTROPHICATION -	The addition of sediments and plant nutrients to a body of water leading to decreased volume and increased biological activity.
EXTERNAL LOADINGS -	The quantity of a given pollutant (for this study, phosphorus) entering a body of water via stormwater runoff originating in its tributary watershed.
GROUNDWATER -	Water located below the soil surface in the zone of saturation where it fills void spaces in soil and rocks. The top level of the groundwater is known as the water table.
HYDROGRAPH -	A continuous graph showing the properties of streamflow (usually flowrate) with respect to time.
HYETOGRAPH -	A graph showing the relationship of rainfall intensity with respect to time.
HYPOLIMNION -	The deep, cold lower level of a stratified lake. This layer is non- circulating except during spring and fall turnovers.
IMPERVIOUS -	A material or surface which does not allow for water penetration.
INTERNAL LOADING -	The quantity of phosphorus released from the bottom sediments of a body of water.
LIMNOLOGY -	The study of the functional relationships and productivity of freshwater biotic communities.
MACROPHYTE -	Large, rooted aquatic plant
MESOTROPHIC -	Waters with a moderate supply of nutrients and, therefore, moderate level of organic production.
NUTRIENT -	A chemical element or compound which promotes the growth and development of organisms.
OLIGOTROPHIC -	Waters in which plant growth is limited by a low chemical concentration of nutrients.

PERMEABLE -	Material or surface which allows for water penetration.
PHOSPHORUS -	Element that is one of the prime nutrients for aquatic plant growth.
PHOTOSYNTHESIS -	Synthesis of organic compounds with the aid of light by chlorophyll-containing cells.
POLLUTANT -	A substance, medium, or agent that causes physical impurity.
RAINFALL INTENSITY -	The rate at which rain is falling at any given instant.
RESIDENCE TIME -	Amount of time a substance will remain in a lake before being flushed or settled out.
RUNOFF -	That portion of precipitation falling on a drainage area that becomes surface flow leading to streams channels.
SECCHI DISK -	A white and black disk 20 centimeters in diameter used to measure transparency (clarity) of lake water.
SEDIMENT -	Particles of material transported to a lake or suspended in its waters. Also refers to bottom material in lakes that result from its formation, the remains of organisms, erosion from land surfaces.
STORM INLET -	A structure that provides for entrance of stormwater runoff. It does not have a sump or depression for trapping solids as in a catchbasin.
STRATIFICATION -	Thermal (temperature dependent) layering of a lake in which the water column is divided by density into a cold lower region and a warm upper region with a relatively thin boundary area between.
THERMOCLINE -	Region of rapid temperature transition in a stratified lake that separates the epilimnion from the hypolimnion.
WATER COLUMN CONCENTRATION -	The concentration (mass per unit volume) varying with depth of a substance within a body of water.
WATERSHED -	Lake area that is drained by a stream or river system.

APPENDIX A

SUMMARY OF USGS ACTIVITIES

INTRODUCTION

At the request of the New York State Department of Environmental Conservation (NYSDEC) and with the cooperation of the U.S. Geological Survey (USGS), New York District, the following is a summary of USGS activities and results for the Irondequoit Bay, Nationwide Urban Runoff Program (NURP) study.

As part of the IBNURP team the USGS had the responsibility to collect, analyze, compile and verify the flow, precipitation, and water quality data used in this study. The data were then used by O'Brien & Gere, the U.S. Environmental Protection Agency (EPA) and USGS for concurrent analysis. While these agencies were using the same data, the analysis procedures and intended goals of each modeling effort were slightly different. The USGS results which follow include loadings and event mean concentrations for eight water-quality constituents, a summary of the Quality Assurance Program and a summary of the USGS Distributed Rainfall/Runoff Routing Model (DR_3M) methodology. While the material does not represent the entire USGS effort, it does complement this report in the development of annual loadings to the bay for seven other constituents and serves to verify our phosphorus loading and modeling efforts.

Two USGS reports are currently being reviewed internally before their release. The Irondequoit NURP Data Report contains daily flow, precipitation and evaporation data for all sites, water-quality analyses for the nine streamflow sites, precipitation quality for four sites, seven partial record sites, and the results of the Quality Assurance Program. The interpretive report details the entire USGS effort of data collection, analysis, and DR3M modeling. The reader is referred to these reports for a more thorough understanding of the USGS effort.

Publication citations for these reports were not available before this printing. The USGS Subdistrict office in Ithaca, New York is the repository for all data and its analyses. The office be contacted by phone: (607) 272-8722 or by mail: U.S. Geological Survey, 521 W. Seneca Street., Ithaca, N.Y. 14850, Attn: NURP project office.

IRONDEQUOIT NURP SUMMARY

Site Descriptions

The selection of sites and water sampling procedures are outlined in Sections 5 and 6 in the main body of this report. Table 1 contains a listing of USGS stations, their identification numbers, and pertinent watershed information. Of these nine continuous monitoring stations, three were located at the outlets of small watersheds less than 0.4 km^2 (1 mi^2) in an area with relatively homogeneous land use. Five stations monitored outlets of major subbasins within the Irondequoit watershed. Of these five, Thornell Road, Thomas Creek, and Allen Creek correspond to the outlets of the subbasins referred to in the main body of the report. The Linden Avenue site includes runoff and loadings from the Thornell and Thomas subbasins and the intervening area to the Linden Avenue Gage on Irondequoit Creek. The Blossom Road site is located downstream of the Allen and Linden subbasins.

DATA COLLECTION

Streamflow Instrumentation

The five NURP sites and the two wetland stations used graphical and punched tape stage recorders for computation of continuous records of discharge. The Allen Creek and Irondequoit Creek at Linden Avenue gages used punched tape recorders only. The East Rochester storm sewer and the downstream wetland site used a combination of velocity sensor and stage recorder for determination of the discharge record. The East Rochester site used a Model 250 Marsh-McBirney recording flowmeter while a Marsh- McBirney Model 201 velocity probe and USGS velocity-stage interface were used in the wetlands for discharge computations.

Streamflow measurements were made at various stages to verify computer generated ratings at culvert sites or to develop rating curves (discharge versus water stage) at non-culvert sites. Verification of flows at the East Rochester storm sewer were made through direct measurement for flows less than 0.140 cms (5 cfs) and by dye dilution techniques for higher flows.

Water-Quality Sampling

Water samples were collected at the five NURP sites and the four other subbasin sites using Manning or Isco water samplers. The samplers were activated as the stream reached a predetermined stage (discharge) or by a flowmeter which activated the sampler when a specified volume of water flowed past the gage. At the more remote sites discrete samples were obtained with hand-held samplers while discharges were determined from rated staff gages. The types of equipment and modes of operation for each site can be found in Table 2.

Meteorologic Data

Precipitation was recorded at 5-minute intervals to the nearest 0.025 cm (0.01 in.) at the five NURP sites. Daily records of precipitation were also collected at 12 locations throughout the basin. During the winter, nine of the observers reported snowfall depth and water equivalents for major winter events.

At the Mendon Ponds site in the southwestern part of the basin, precipitation was recorded continuously by a weighing bucket raingage. Evaporation was measured daily at this site by a Class-A evaporation pan.

Atmospheric Quality

Four atmospheric quality monitoring stations were located within the Irondequoit basin. Three sites, Mendon Ponds, East Rochester, and Southgate, used Aerochemetrics Model 301 wetfall/dryfall samplers. The fourth site, near Pittsford, collected both wet and dryfall in a bulk deposition collector during the non-winter period. The dryfall and bulk collection containers were removed for analysis on the first Tuesday of each month. Wetfall containers were removed for analysis after rainfall events of 1.25 cm (0.50 in.) or more. Field collection and sample analysis was accomplished by Monroe County Environmental Health Laboratory (EHL) personnel following procedures outlined in the USGS

Quality of Water Branch Technical Memo 81.23 (1981). Results of these analyses can be found in Tables 3 through 6.

Sample Collection

As stated in the main body of the report, each site was manned by Monroe County EHL personnel during storm events. While all samplers were automatically activated, sample collection rates varied with the type of storm and resulting flows. During major storm events both EHL and USGS personnel collected cross-sectional samples to verify sampler efficiencies and collected samples for laboratory quality assurance analyses. Discharge measurements for rating curve verification were also taken during these storms.

The rate of sample collection was always preset to the highest sampler setting, generally one sample every 3.7 minutes. This rate was then adjusted for the storm intensity and flow conditions monitored by the personnel who maintained each site.

The samples were transported to the Environmental Health Laboratory where they were logged in and composited for analysis. The criteria for compositing samples were dependent on the number of samples collected for each part of the hydrograph (i.e. rising limb, peak, recession) and on the storm characteristics. The final composite scheme was determined by the person who maintained the station during the storm.

Quality Assurance/Quality Control Program

As part of the data collection and analysis program, a Quality Assurance/Quality Control (QA/QC) plan was developed for the IBNURP project (Schroeder, Troutman, 1980). The objective of this plan was to insure that the data collected was both accurate and precise. The QA/QC plan involved careful scrutiny of streamflow monitoring and sample collection procedures and also carried through the analysis of the samples and final data verification and reporting. Streamflow monitoring, as outlined in Techniques of Water-Resource Investigations, (Carter and Davidian, 1968, Buchanan and Somers, 1969), was strictly followed to assure accurate flow measurements.

The primary concern in sample collection was the proper location of the sampler orifice within the stream cross-section. To verify that the sampler was collecting a representative stream sample, cross-sectional water samples were collected coincident with the automatic sampler. Comparison of these samples provided data to determine a "sampler efficiency" for each site. Preliminary review of the data lead to a few minor modifications in sampling apparatus. Final analysis of the data confirmed that the orifice for each sampler was within the well-mixed portion of the stream and there was no bias in the samples collected. At several sites there were a few periods when an eddy or backwater condition developed due to debris accumulation. Removal of the debris during and after storms kept these problems to a minimum.

Strict laboratory quality control procedures were maintained as the samples arrived at the Monroe County Environmental Health Laboratory. The samples were logged in and composited for analyses following specified procedures (Schroeder and Troutman, 1980, Technical Coordination Plan- USGS/EPA Urban Hydrology Studies, 1980). Quality assurance procedures (Skougstad, et al, 1979; Friedman and Erdmann, 1981) were maintained in both the USGS Atlanta Laboratory and the Monroe County Environmental Health Laboratory for analyses on all samples. Reports of quality assurance procedures and results for the USGS Atlanta Laboratory are available from the Quality of Water Branch, U.S. Geological Survey, Reston, VA 22092.

The Monroe County Environmental Health Laboratory maintained similar QA/QC procedures. The analysis of the county QA/QC data is compiled in the USGS data report. These data summarize the analysis of laboratory standards, recovery of laboratory spikes and duplicate analyses. The Monroe County EHL also participated in the analysis of unknowns or reference water samples from the NYS Health Department, USEPA and the USGS. The results from these tests and the analyses of the county's quality control reports indicate that the Monroe County EHL was proficient in all analytical procedures. The accuracy and precision of analysis provided reliable data for the modeling of the Irondequoit basin.

Data Analysis

Streamflow and precipitation data were analyzed by computer to provide an average daily value (DV) for flow and precipitation at each station. These site-specific data were input into the USGS WATSTORE DV file. For designated storm events, the data were re-analyzed to develop unitized (5 or 15 minute) flow and precipitation files (UV) for each site. The USGS analysis only considered Type I and II storms which involved the higher rainfall intensities, runoff volumes, and the greatest number of water-quality samples to define the storm hydrograph.

The water-quality analysis results were gathered from the various laboratory sources and compiled into the USGS WATSTORE Water-Quality file and NURP Data Management Systems. The data were then verified by personnel from the Monroe County EHL, USGS, and O'Brien & Gere. After extensive verification of all the data, the DV and UV files for flow and precipitation were merged with the water-quality files to develop the Irondequoit NURP master data set. This master data set was then available for analysis by USEPA, USGS, and O'Brien & Gere. The master file, minus UV flow and precipitation data, will be available in the USGS data report. The UV data is available from the USGS computer files or is on record in the Ithaca Subdistrict office.

Within the NURP data management system, programs were used to analyze the Irondequoit master file. The programs ranged from statistical analysis packages to general utility programs. The reader is referred to the USGS Open-File Report 82-442, Data Management System for USGS/USEPA Urban Hydrology Studies Program (W.H. Doyle, Jr. and J.A. Lorens, 1982) for more information.

Through use of the Data Management System, storm loadings and event mean concentrations for eight parameters were computed. The eight parameters chosen were total phosphorus (TP), total Kjedahl nitrogen (TKN), chemical oxygen demand (COD), suspended solids (SS), chloride (Cl), lead (Pb), cadmium (Cd) and zinc (Zn). These parameters were chosen by the NURP technical team based upon the review of all parameters analyzed by the Monroe County Environmental Health Laboratory and the USGS Laboratory (pp. 47-48 in the main body of this report) during the period July 1980 to September 1981. These eight parameters were found to be the most significant or of greatest concern by the technical team.

Estimation of Annual Loadings

While data collection efforts of the IBNURP study focused primarily on storm events, the frequency of water-quality sampling throughout the rest of the study period was sufficient to develop an estimate of the annual loading for each of the eight constituents. Data used in this estimate were collected during the period August 5, 1980 through August 31, 1981. These data were aggregated into five sampling periods.

Storm loadings were calculated for each of 13 storm events identified during this period through the use of the event mean concentration (EMC). Since water-quality sampling typically did not extend throughout the entire duration of a storm event, the flow-weighted average concentration of each constituent was computed for the sampled portion of the event. This computed EMC was then applied to the total runoff recorded for the event to obtain the storm loading. Loadings were computed in a similar manner for the snowmelt period occurring in February 1981.

In addition to the 13 storm events and the snowmelt period, three other sampling periods were defined to extend the analysis to the remainder of the year. The summer/fall baseflow period included all intervening days between storm events and covered the period of mid-May through October. The winter and spring runoff periods completed the annual cycle and covered the months of November through January and March through mid-May, respectively. These latter two periods included both baseflow conditions and storm events which were not sampled in detail during this study. Loadings for all three periods were computed using the flow-weighted average concentration (EMC) measured during the period and the total runoff volume recorded.

Tables 7 through 14 present the annual loading summaries for eight stations. Precipitation and runoff are reported along with the EMCs and loadings computed for each of the defined intervals. Also included in the tables are the total loadings for the 13 storms sampled during the study and an estimate of the total annual loading. It is important to note that the periods of record for two of the stations, East Rochester and Blossom Road, do not cover the entire study period due to the absence of continuous discharge data. Comparisons with these two stations are limited to the available record.

Concentration Ranges and Constituent Loadings

Measured concentrations of each constituent were highly variable during the study period and typically covered three orders of magnitude. Figures 1 to 8 present the maximum and minimum concentrations measured at each station for all eight constituents. The figures also contain the range in EMC computed for the 13 storm events. Also included for reference are water-quality standards, where applicable. Drinking water standards have been adopted for four of the constituents (Safe Drinking Water Act, 1974), while water-quality standards protecting aquatic life exist for six constituents. The Great Lakes Nearshore Index (Schierow, et al, 1981), was selected as a relevant standard for five constituents and the LC_{50}* reported by the EPA (EPA, 1981) was selected for the remaining constituent.

Suspended Solids

The snowmelt event accounted for over 50 percent of the annual suspended solids loading, while the sample storm events contributed another 20 percent to the annual loading. The estimated loading rate was 25-30 tons/km^2 for all subbasins except Thomas Creek, which yielded 4 ton/km^2. The highest loading rate for the three land use sites was measured at East Rochester. The EMC computed for each sampling period was above the GLNI with the exception of the spring runoff period. The average EMC at Blossom Road was six times the Great Lakes standard.

Total Phosphorus

Total phosphorus loadings showed a seasonal pattern similar to suspended solids with the snowmelt period accounting for nearly 50 percent of the total and the sampled storm events contributing an additional 20 percent. Loading rates were highest for the Allen Creek and Linden[1] subbasins and averaged 50 kg/km^2, nearly twice the rate for

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*LC_{50} - Concentration that is lethal (fatal) to 50 percent of organisms tested in a specified time.

[1] The Linden subbasin in this appendix should not be confused with the Central subbasin found in the main body of this report.

Thornell and Thomas Creek. East Rochester was the major contributing land use site. As indicated in Figure 2, computed EMCs were above the level of total phosphorus associated with the mesotrophic/eutrophic boundary for fresh water lakes. The average EMC at Blossom Road was ten times this value.

Total Kjeldahl Nitrogen

The seasonal distribution of TKN loadings closely followed the pattern exhibited by total phosphorus loadings. The snowmelt event accounted for 40 percent of the annual loading and the storm events provided an additional 15 percent. The Allen Creek and Linden subbasins recorded the highest loading rates, 500 kg/km^2, ten times the phosphorus loading rate. East Rochester was the major contributing land use site. The average EMC was 1-2 mg/l with no water-quality standards being reported for TKN.

Chemical Oxygen Demand

The annual COD loading was more equally distributed among the sampling periods with the major part of the loading appearing during the snowmelt and spring runoff periods. Loading rates of 3-4 $tons/km^2$ were calculated for the Allen Creek and Linden subbasins, twice the rate recorded for Thornell and Thomas Creek. East Rochester was again the major contributing land use site. The average EMC computed for Blossom Road was 15 mg/l, which is below the 20-30 mg/l BOD concentration typically found in secondary treatment plant effluent. Since the COD analysis measures a greater portion of organic material than does the BOD analysis, the COD loadings reported for Blossom Road are much less than those which would be associated with treatment plant effluent.

Chloride

Annual chloride loadings were evenly distributed throughout the winter runoff, snowmelt and spring runoff periods. The sampled storm loadings accounted for 10 percent of the total. Computed loading rates for the Allen Creek and Linden subbasins were 50 $tons/km^2$, four times the rates estimated for Thornell and Thomas Creek. The Southgate site was the major land use contributor. EMCs computed for all sampling periods were above the GLNI, and the average EMC at Blossom Road was five times greater than the standard.

Lead

The snowmelt and spring runoff periods accounted for nearly 70 percent of the total lead loadings, while storm events contributed another 20 percent. The Allen Creek subbasin recorded the highest loading rate, 15 kg/km^2, three times the rate for the Linden subbasin and eight times the rate for Thornell and Thomas Creek. East Rochester was the major contributing land use site. EMCs for lead were slightly above the GLNI for most stations throughout the year. The average EMC computed at Blossom Road was equal to the level reported for the standard.

Zinc

The snowmelt period contributed 60 percent of the total zinc loading with an additional 10 percent provided by the sampled storm events. Loading rates of 160 kg/km^2 were computed for the Allen Creek and Linden subbasins. A loading rate of 130 kg/km^2 was estimated for Thomas Creek and 90 kg/km^2 for Thornell. Southgate was the major contributing land use site. Zinc EMCs were high compared with values reported in the literature but near the 1.0 mg/L level reported as the LC$_{50}$ by the EPA for general aquatic life. This concentration is below the LC$_{50}$ reported for brook trout (5.5 mg/L). The average EMC recorded at Blossom Road was 0.74 mg/L.

Cadmium

Nearly 75 percent of the annual cadmium loading appeared during the spring runoff, while only 5 percent was recorded during storm events. The highest loading rate was 4 kg/km^2 recorded for the Allen Creek subbasin, nearly twice the rate computed for the other subbasins. There was no difference in loading rates among the land use sites. EMCs for cadmium were three to six times the drinking water standard during the spring runoff period though generally less than the standard throughout the rest of the year.

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Summary

Pollutant loadings were generally higher during the snowmelt and spring runoff periods, with the sampled storm events contributing less than 20 percent of the total loading. Loading rates for subbasins were highest at the Allen Creek and Linden Avenue sites, while East Rochester was the major contributing land use site for all constituents except chloride, zinc, and cadmium. Sample period EMCs were above the GLNI for suspended solids, total phosphorus and chloride, and nearly equal to the GLNI for lead, zinc and cadmium.

THE DISTRIBUTED RAINFALL RUNOFF ROUTING MODEL (DR_3M)

Purpose

The rainfall/runoff simulation package selected for the IBNURP study was developed by the U.S. Geological Survey and documented in Open-File Report 82-344, User's Manual, Distributed Rainfall/Runoff Routing Model (William M. Alley and P. E. Smith, 1982). One objective of the modeling effort was to test the applicability of the DR_3M and DR_3M-QUAL models designed for use in small watersheds of less than 0.33 km^2 in area on larger areas comprised of different land uses. Application of these models to larger areas such as the Allen Creek watershed violates some of the assumptions upon which the models are based. Testing the severity of these violations and the sensitivity of the models to various input data constituted an important part of the Irondequoit NURP project. In addition, model-derived estimates of surface accumulation and washoff rates for the selected constituents amplified EPA's national data base characterizing surface loadings of various surface water pollutants.

A further objective of the modeling process was to develop a tool useful in the analysis of strategies for nonpoint source pollutant abatement. One model application of particular interest to the Irondequoit basin is the simulation of the effects of detention basins in attenuating storm hydrographs and reducing pollutant loadings through settling of suspended particulates.

Model Structure

The DR_3M model applied to the Irondequoit basin consisted of two parts, one to simulate the relationship between rainfall and runoff (DR_3M) and the other to simulate the accumulation and washoff of pollutants from the land surface (DR_3M-QUAL). The models were developed to simulate runoff and pollutant loads occurring in small, <0.4 km^2 (<1 mi^2) watersheds where flow paths are short and complex interactions (eg. interflow, varying baseflow) are not significant. The models have not been applied in northern climates where snow is a factor. Each model was run in two modes: a "lumped parameter mode" in which the entire watershed was treated as a blackbox and a single output (eg. centimeters of storm runoff or kilograms of total phosphorus) was determined at the outlet, or a "distributed mode" in which the watershed was subdivided into segments to simulate the time dependent flow of water and pollutants through the watershed. The models provided detailed simulation of the quantity and quality of storm-runoff events during days for which short-time interval or "unit data" were input to the program. Between these unit days, the model used daily precipitation data to provide a continuous accounting of soil moisture and impervious area surface loads on a daily basis.

Model Description

DR_3M

The watershed was conceptualized as a set of pervious and impervious surfaces linked to the basin outlet by a series of channels. In the lumped parameter mode the model computed the total runoff volume generated by a storm event for the defined physical configuration. The model assumed all rainfall received by effective impervious surfaces (eg. streets and driveways) appeared as runoff once depression storage had been filled. Rainfall on non-effective impervious surfaces (eg. rooftops) was transferred to pervious surfaces. Runoff originating from pervious surfaces was computed from a soil moisture capacity and percolation rate, rainfall rate, and antecedent moisture conditions. The storm runoff volume calculated by the model was made to approximate the measured value by adjusting the soil parameters and the percentage of effective impervious area.

In the distributed mode, the pervious and impervious surface areas characterized in the lumped-parameter mode were apportioned among a network of overland flow segments representing the watershed surface. Given the length, slope and roughness of these overland flow segments and the channel segments into which they drained, the model calculated the runoff occurring from each segment for a range of time intervals during storm events. From this detailed information, the composite storm hydrograph for the basin outlet was computed.

DR_3M-QUAL

Water quality of storm runoff was simulated by adding the pollutant contributions from impervious areas, pervious areas, and precipitation. In the lumped-parameter mode, the model computed pollutant loadings to receiving waters, summarized in terms of pounds of pollutants passing the watershed outlet during the storm. Impervious area runoff quality simulated by the model was calculated on the basis of constituent accumulation and washoff equations which continuously determined the magnitude of surface loads. Pervious area loadings were generated through use of equations defining the quantity of sediment produced by the storm event and the concentration of the pollutant within the sediment. The model-predicted storm loadings were adjusted to approximate the measured loads by varying the parameter values in these equations.

The water quality model accepted as input data the storm hydrographs computed for each watershed segment by the rainfall-runoff model, DR_3M. With these data, the model can be applied in the distributed mode to predict "pollutographs" (constituent concentration vs. time) at the watershed outlet. Detention storage by reservoir segments was included as a model option to calculate the reduction in storm loads through particulate settling.

Modeling Methodology for Irondequoit Basin

Five watersheds were selected to test the application of the DR_3M and DR_3M-QUAL models for the Irondequoit basin. Three sampling stations, Cranston Road, Southgate and East Rochester, provided information concerning runoff loadings from watersheds less than 0.4 km^2

($1\ mi^2$) in area with relatively homogeneous land use. Data from the much larger 108 km^2 ($41.9\ km^2$) watershed upstream of Thornell Road were used to simulate storm runoff from an agricultural basin. The modeling results for these four land-use watersheds were then used to develop a model for the Allen Creek watershed, encompassing 66.6 km^2 (25.7 mi2) and comprised of varying land uses. Comparison of predicted storm runoff loadings for the Allen Creek model with those actually measured tested the feasibility of transferring findings from small watersheds to those much larger in surface area. The same eight water quality constituents mentioned earlier were selected for this analysis: total phosphorus, total Kjeldahl nitrogen, chemical oxygen demand, suspended solids, chloride, lead, cadmium, and zinc.

The calibration procedure used in developing the five watershed models consisted of two parts. Initially the results of the lumped-parameter runs with DR_3M were optimized to predict the total volume of storm runoff events as closely as possible. Several DR_3M-QUAL runs were then made for each watershed in the lumped-parameter mode to improve the predictions of storm event loadings for the selected water quality constituents. Of the 13 storm events selected for the analysis, data for seven were included in the calibration process.

Data for the remaining storms were used in a final run to verify the model results. The standard error and chi-square statistic were computed for each of the storm runoff and runoff quality models to quantify the accuracy of the model predictions.

The DR_3M was applied in the routing mode to three of the watersheds to simulate storm hydrographs at the watershed outlet. These models were calibrated by modifying the characteristics of the overland flow and channel segments to match the peak runoff discharge for each storm event. These models were then coupled with the DR_3M-QUAL models to simulate the effects of detention storage on the attenuation of the storm hydrograph and pollutograph.

The results of this modeling effort will appear in a forthcoming publication by the U.S. Geological Survey. The results and the simulation models themselves reside at the U.S. Geological Survey Subdistrict office in Ithaca, New York.

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FIGURE 1.—CONCENTRATION RANGES FOR SUSPENDED SOLIDS

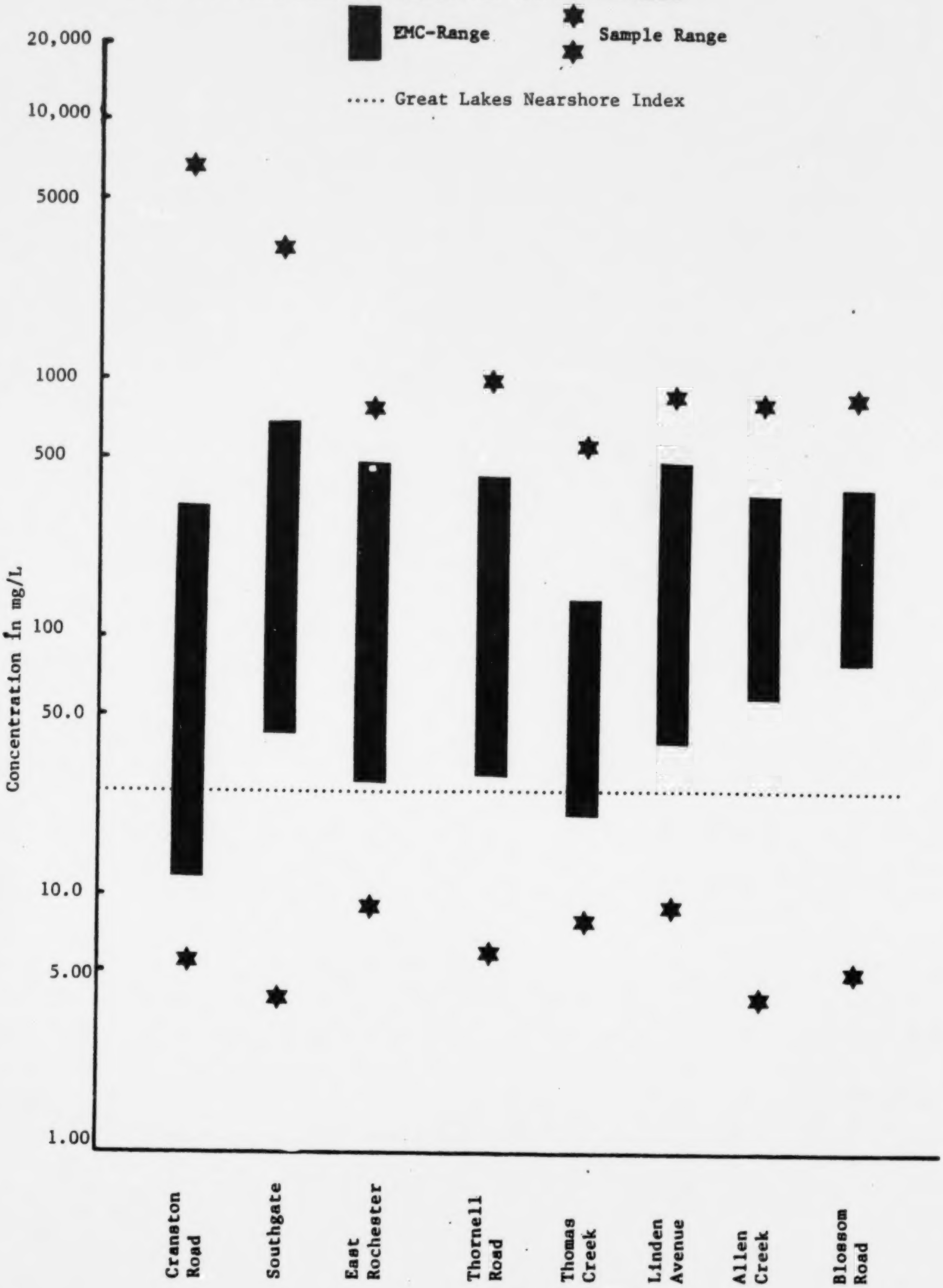

FIGURE 2.—CONCENTRATION RANGES FOR TOTAL PHOSPHORUS

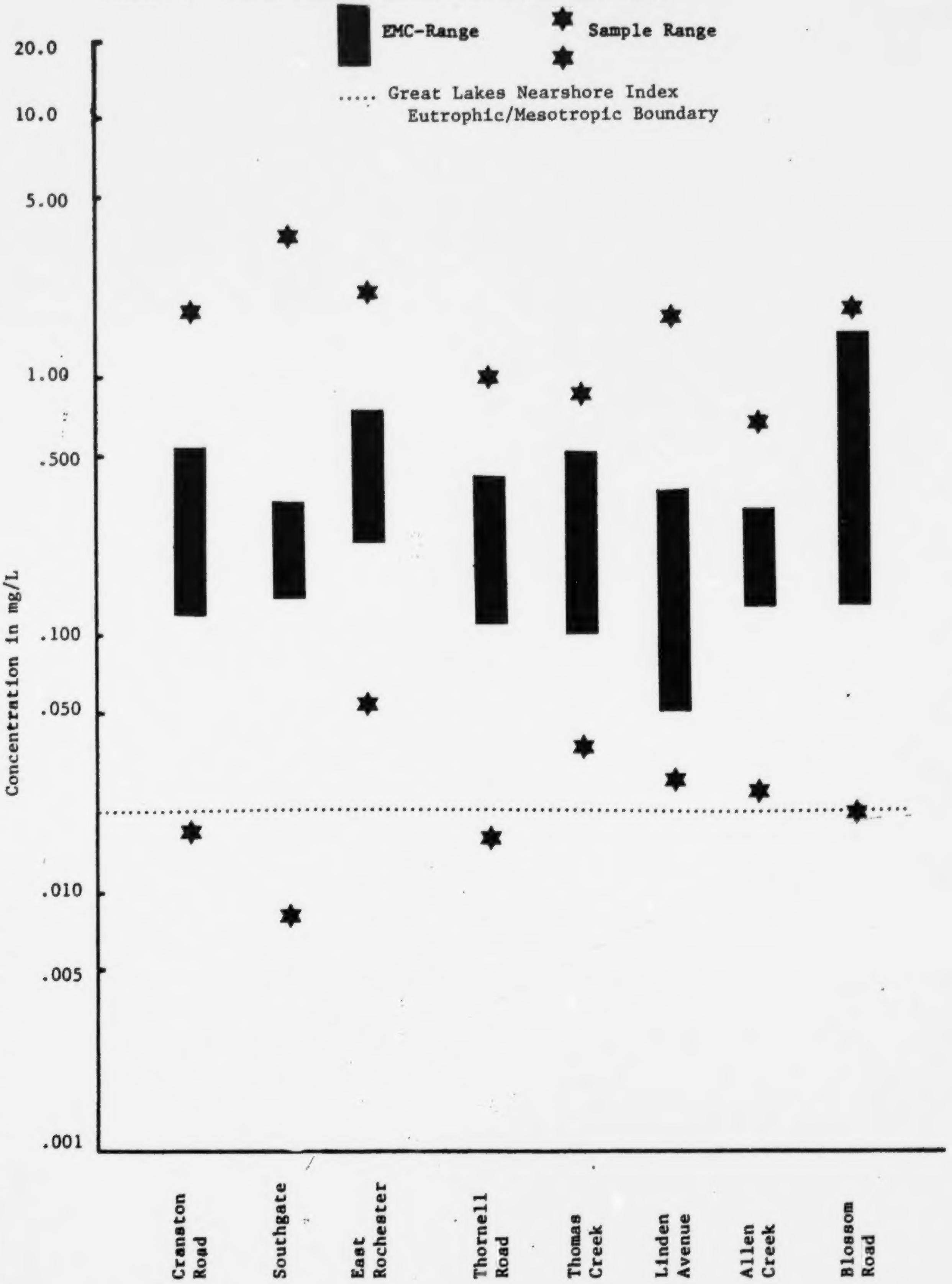

FIGURE 3.—CONCENTRATION RANGES FOR TKN

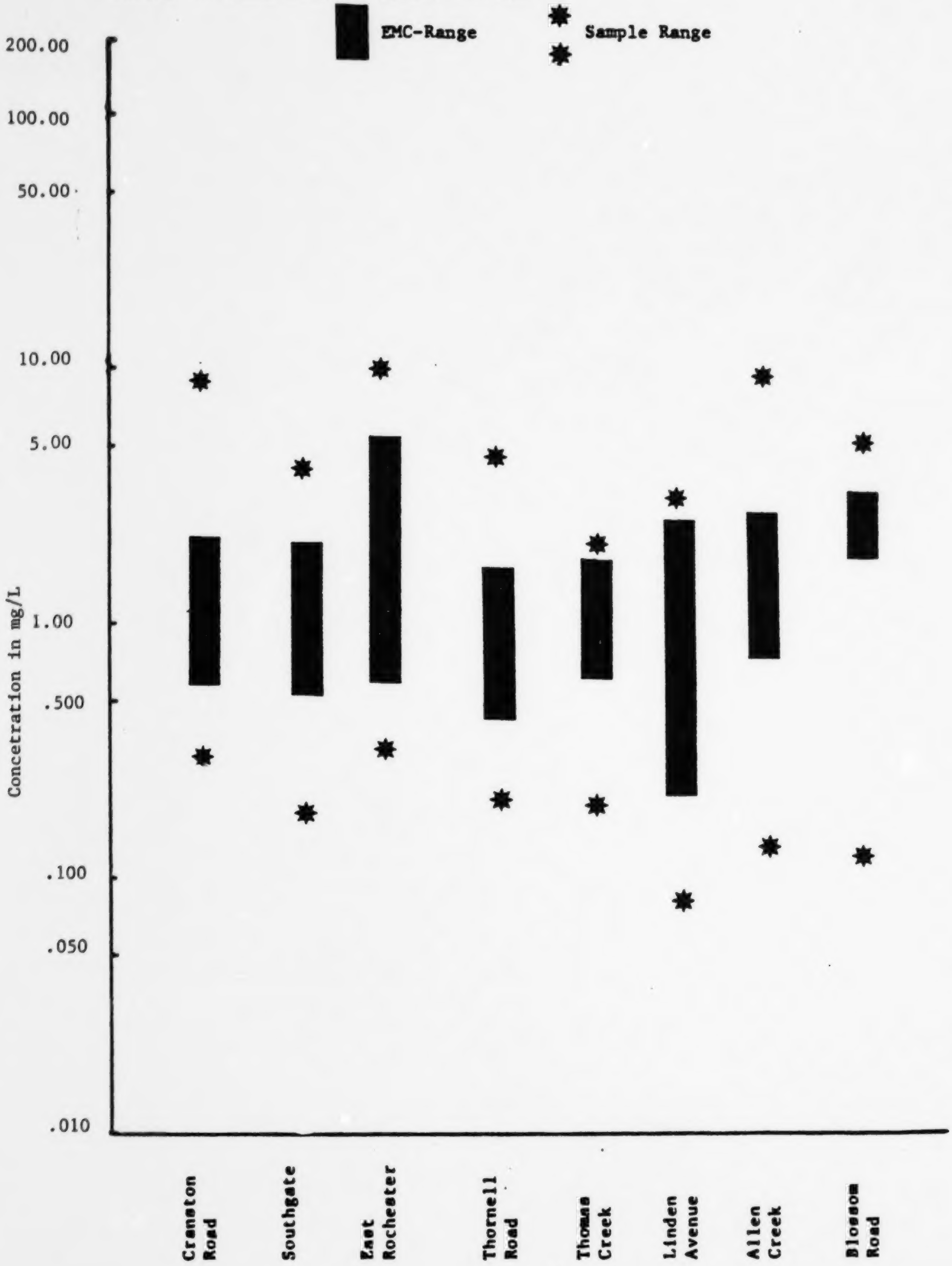

FIGURE 4.—CONCENTRATION RANGES FOR COD

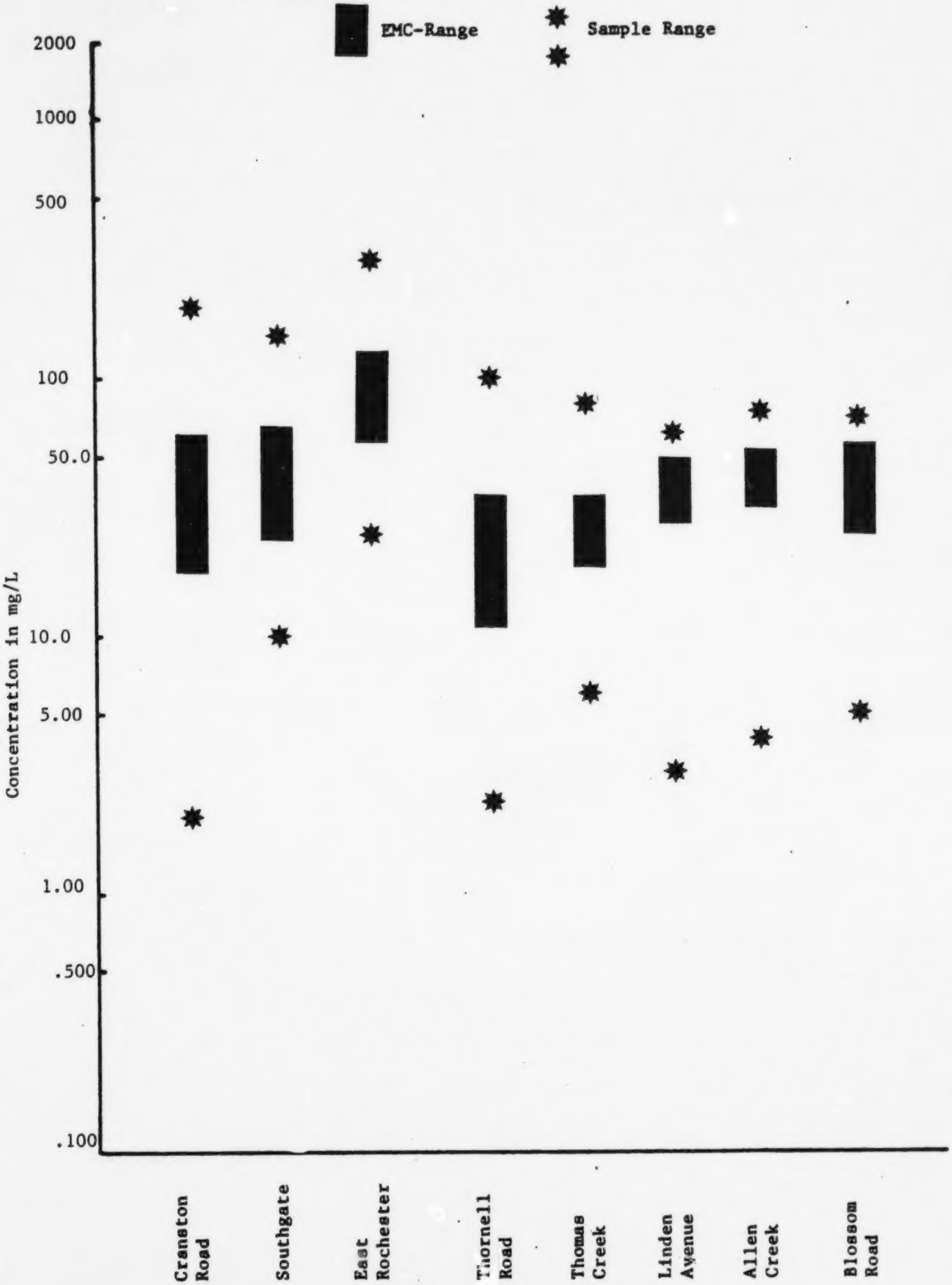

FIGURE 5.--CONCENTRATION RANGES FOR CHLORIDE

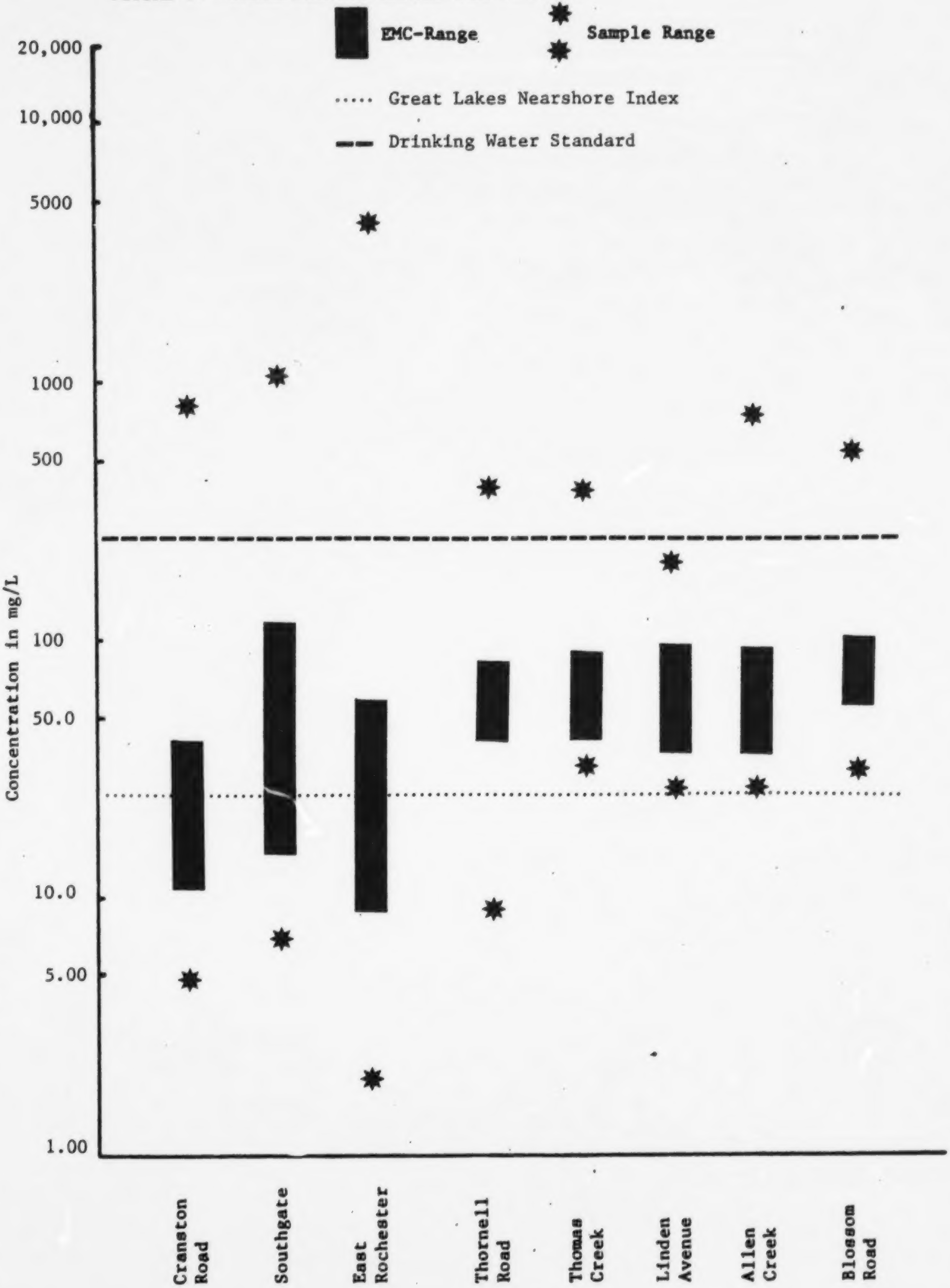

FIGURE 6.--CONCENTRATION RANGES FOR LEAD

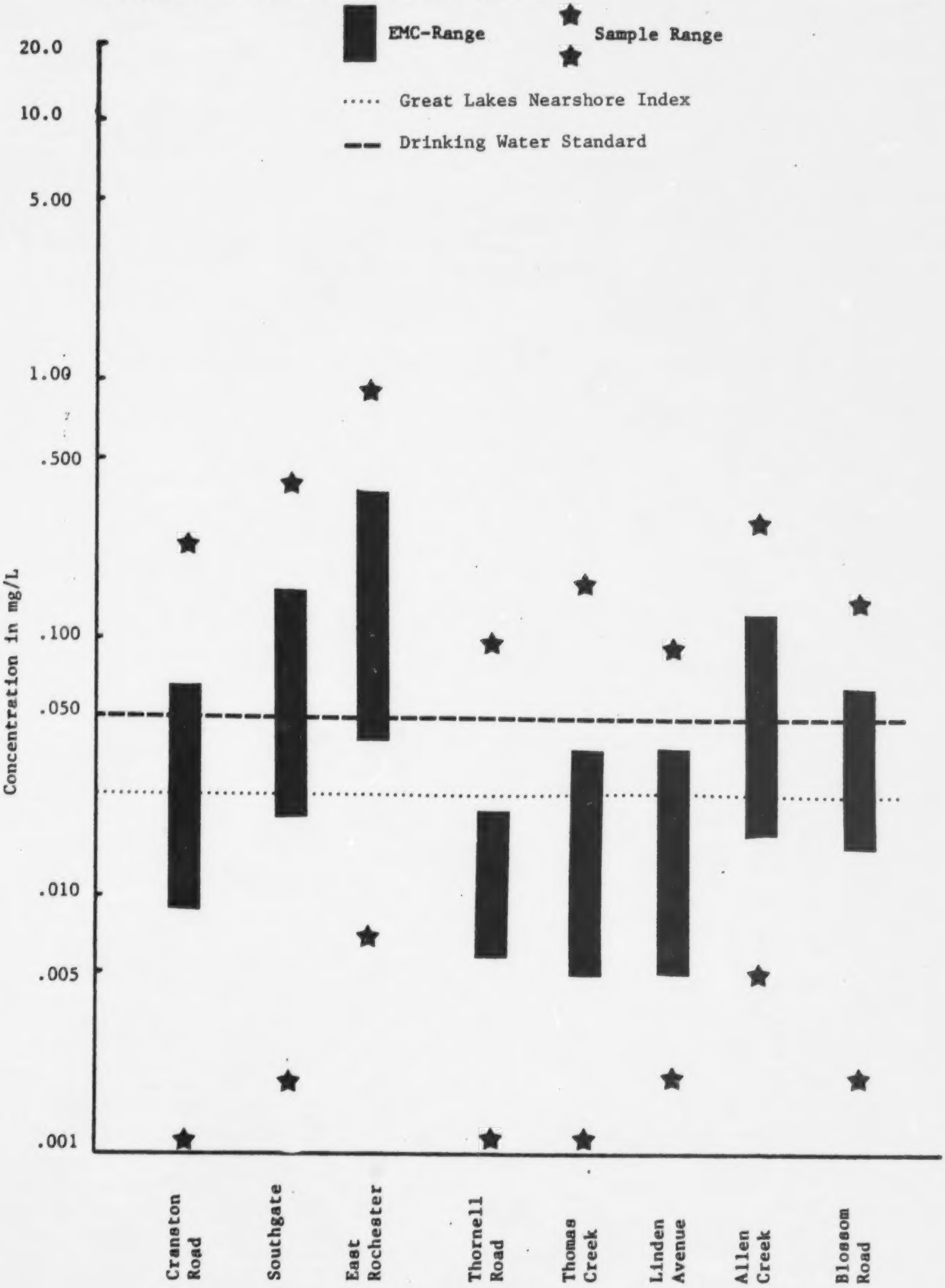

FIGURE 7.—**CONCENTRATION RANGES FOR ZINC**

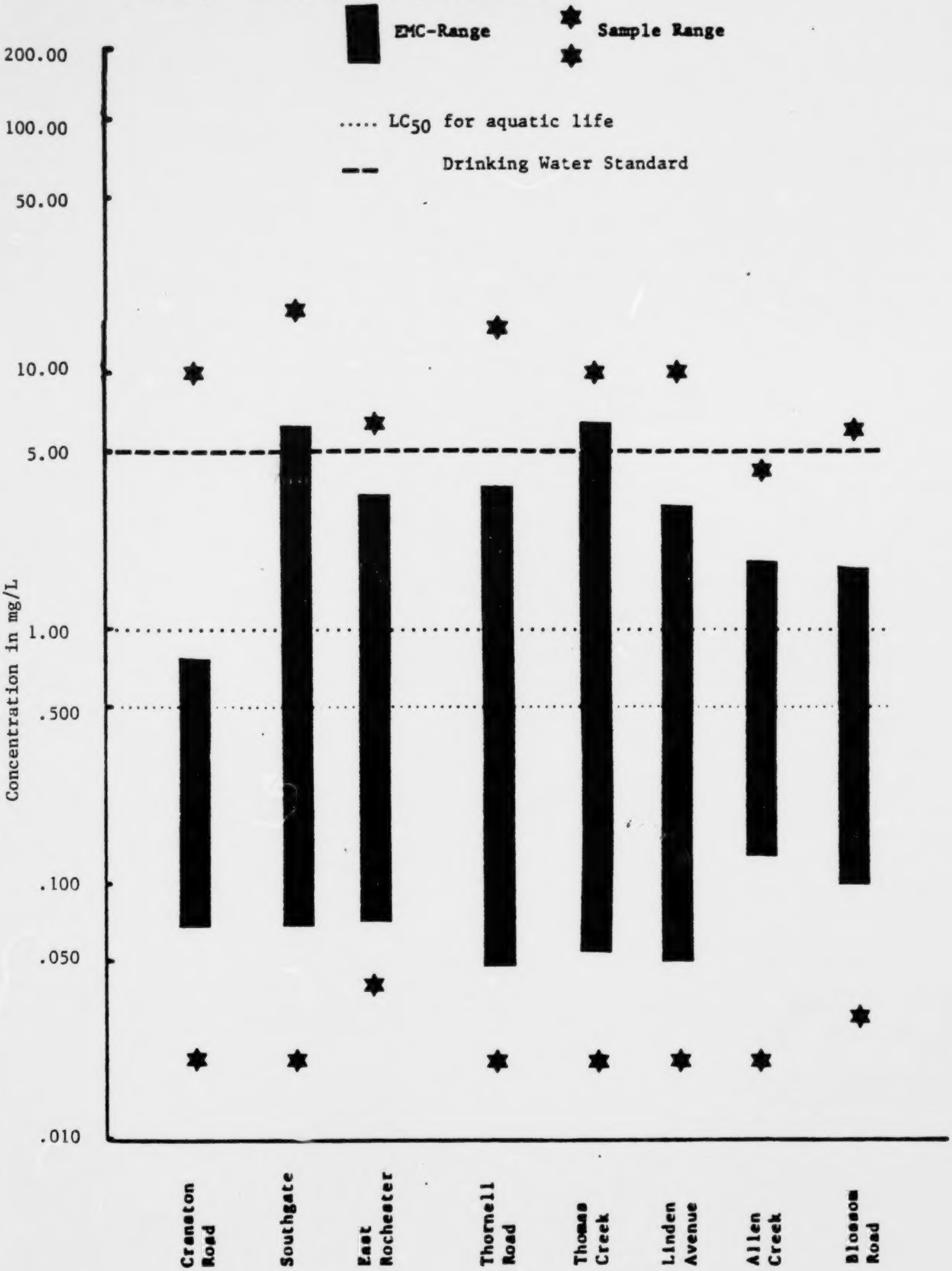

FIGURE 8.—CONCENTRATION RANGES FOR CADMIUM

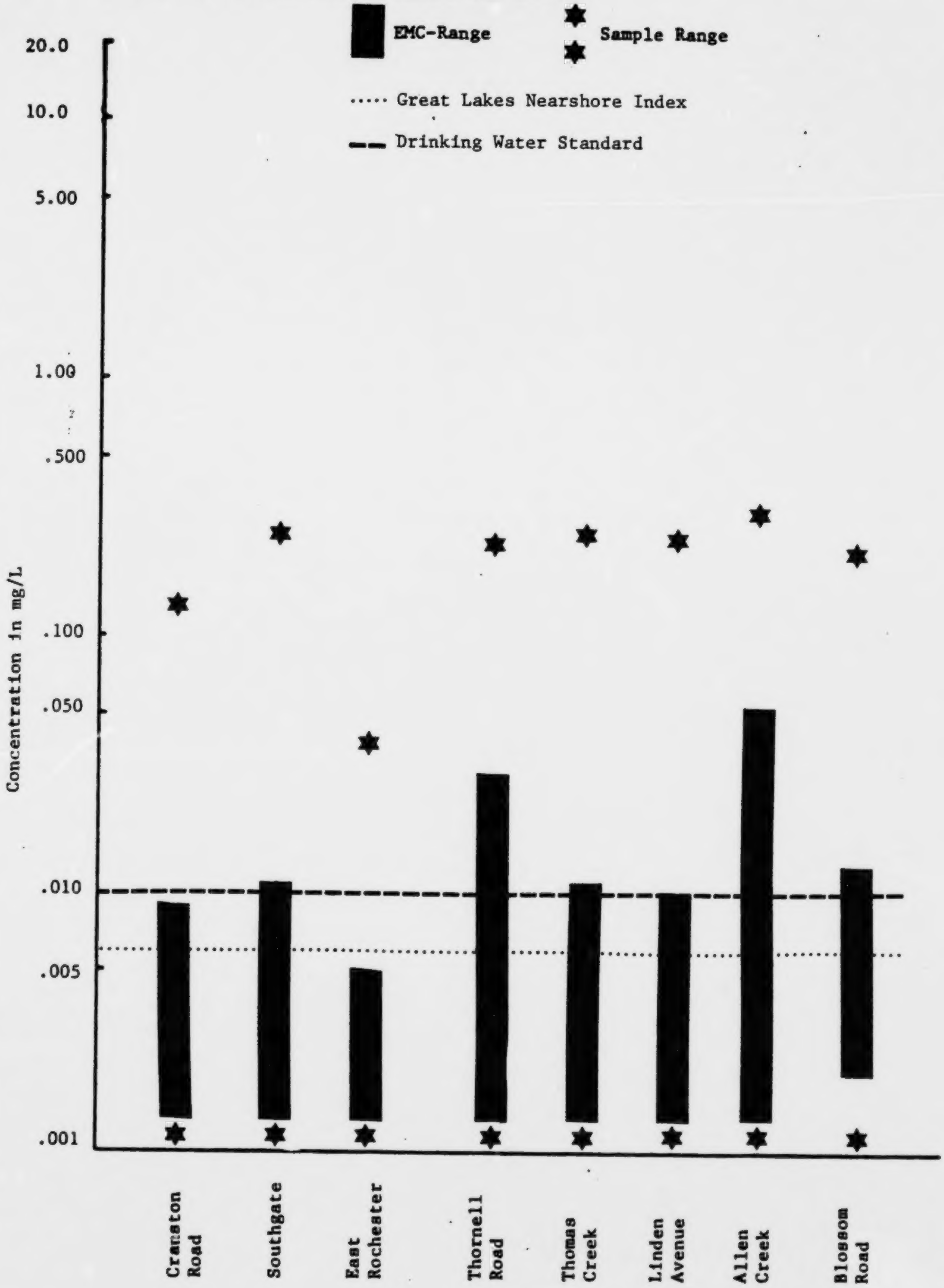

TABLE 1 - STATION IDENTIFICATION AND WATERSHED INFORMATION FOR THE IRONDEQUOIT NURP STUDY

	Topographically measured data						Model derived data		
	Station no.	Station name	Latitude Longitude	Drainage area (Km) (Mi)	Basin slope m/m (ft/ft)	General landuse description of subbasin	Modeled drainage area (Km) (Mi)	Drainage area remarks	Percent b/ effective impervious
NURP SITES	W1 04232040 43031507729280	Irondequoit Cr nr Pittsford,NY (Thornell Rd)	43°03'15" 77°29'28"	115 (44.4)	.013 (.044)	Agricultural, rural, undeveloped, open-channel streams, soils moderately well drained.	115 (44.4)	-	1.7
	W2 43040307731150	Trib to Barge Canal Trib nr Pittsford,NY (Cranston Rd)	43°04'03" 77°31'15"	0.673 (.26)	.011 (.035)	Moderate density residential, storm sewers and lined swales, soils moderately well drained.	0.673 (.26)	-	15.2
	W3 43042807726110	White Br Trib nr Fairport,NY (Southgate Rd)	43°04'28" 77°26'11"	.930 (.360)	.013 (.043)	Shopping plaza with surrounding residential development, storm sewers and unlined ditches.	.725 (.280)	Boundary changed due to construction, early in project	15.2
	W4 04232046 43062307727430	Thomas Cr at Fairport, NY (BOCES)	43°06'23" 77°27'43"	73.8 (28.5)	.013 (.044)	Rural, undeveloped headwaters, transitional downstream, generally open-channel streams w/contiguous wetlands Soils mod. to excessively well drained	71.7 (27.7)	Noncontributing areas draining to Barge Canal 2.07 km2 (0.80 mi)	2.2
	W5 43064907728550	Trib of Irondequoit Cr at E.Rochester,NY (storm sewer)	43°06'49" 77°28'55"	1.55 (.60)	.004 (.013)	High density residential, storm sewered throughout, soils excessively well drained.	1.40 (.54)	Noncontributing areas draining to surficial aquifer 0.16 km (0.06 mi)	16.8
SUBBASINS	W6 04232047 43071507728380	Irondequoit Cr at Linden Ave, E.Rochester,NY	43°07'15" 77°28'38"	262 72.8 a/ (101)(28.1)	.008 (.027)	Mixed residential/commercial, storm sewers w/some open-channels, soils poorly to moderately well drained.	249 72.8 a/ (96) (28.1)	Noncontributing areas draining to Barge Canal 12.8 km (4.95 mi)	8.1
	W7 04232050 43074907731080	Allen Cr nr Rochester NY	43°07'49" 77°31'08"	78.0 (30.1)	.011 (.035)	Moderate to high density residential, storm sewers w/some open-channels, soils poorly to moderately welldrained	66.6 (25.7)	Noncontributing areas draining to Barge Canal 11.4 km^2 (4.40 mi^2)	6.9
	W8 43085007730460	Irondequoit Cr at Blossom Rd, Rochester, NY	43°08'50" 77°30'46"	370 (143)	.008 (.027)	Entire basin (includes all the above)	342 (132)	Noncontributing areas draining to Barge Canal and surficial aquifers 28.5 km (11.0 mi^2)	7.8
	W9 43095807731560	Irondequoit Cr at Landfill Narrows, Rochester, NY	43°09'58" 77°51'36"	373 (144)	.008 (.027)	Entire basin including upper Irondequoit wetland	344 (133)		7.8

a/ Intervening area between Linden Avenue and the Thornell Road and Thomas Creek stations.

b/ As determined by DR$_3$M

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TABLE 2 - NURP SITE SAMPLERS AND MODE OF OPERATION

SITE	SAMPLER TYPE	MODE OF OPERATION	SAMPLER INTAKE CHARATERISTICS
IRONDEQUOIT CREEK NR PITTSFORD,NY 04232040	Manning model S-4040 sequential sampler	Stage Activated/Time Mode: Activation switch connected to sampler power supply allowing time mode samples to be collected 0.45 ft. above base flow. (Sampler initially activated on a flow proportional basis after 550,000 gallons) Sampler set at 500 ml sample (2 per bottle) on 15, 30, or 60 minute intervals depending on flow.	Approx. 20 feet of line with 4 foot vertical lift
TRIB TO BARGE CANAL TRIB NR PITTSFORD,NY 430403077311500	Manning model S-4040 sequential sampler	Flow proportional-sampler primarily activated by a Manning model F-3000A flow meter. A 500 ml sample (2 per bottle) was initiated every 11,540 gallons when the stage reached approx. 0.4 foot above base flow. Sample interval changed depending on flow condition	Approx. 15 feet of line with 5 foot vertical lift
WHITE BROOK TRIB NR FAIRPORT,NY 430428077261100	Manning model S-4040 sequential sampler	Flow proportional-sampler primarily activated by a Manning Model F-3000A flow meter. A 500 ml sample (2 per bottle) was initiated every 44,900 gallons after the stage activation switch closed approx. 0.4 ft. above base flow. Sample times were recorded as a glitch on flow meter chart. Sample interval switched according to flow conditions.	Approx. 20 feet of line with 5 foot vertical lift
THOMAS CREEK AT FAIRPORT,NY 04232046	Manning S-4040 sequential sampler	Flow proportional-sampler activated after every 135,000 gallons by a Manning model F-3000A flow meter. Interval changed or sampler switched to a time mode depending on flow conditions.	Approx. 35 feet of line with 12 foot vertical lift
IRONDEQUOIT CREEK TRIB AT EAST ROCHESTER,NY 430649077285500	Manning model S-4050 sequential sampler	Flow proportional-sampler activated after every 13000 gal by a model 250 Marsh-McBirney velocity modified flow meter. Sampler set at two 500 ml samples per bottle. Sample times were recorded on a 4/20 M-amp Rustrack recorder wired to the power supply of the vacum pump. Sample interval varied depending on flow conditions.	Approx. 20 feet of line with 16 feet vertical lift

TABLE 2 - NURP SITE SAMPLERS AND MODE OF OPERATION (Cont'd)

SITE	SAMPLER TYPE	MODE OF OPERATION	SAMPLER INTAKE CHARATERISTICS
IRONDEQUOIT CREEK AT LINDEN AVENUE, EAST ROCHESTER,NY 04232047	Manning Model S-4040 sequential	Stage Activated/Time Mode: Sampler set for two 500 ml samples per bottle at intervals of 30 or 60 minutes depending on flow conditions.	Approx. 20 feet of line with 10 foot vertical lift
ALLEN CREEK NEAR ROCHESTER, NY 04232050	Manning model S-4040 sequential	Stage Activated/Time Mode: Sampler set for two 500 ml samples per bottle at intervals of 30 or 60 minutes depending on flow conditions.	Approx. 25 feet of line with 10 foot vertical lift
IRONDEQUOIT CREEK AT BLOSSOM ROAD, NR ROCHESTER, NY 430850077304600	Manning model S-4040 sequential	Time Mode: Sampler set for two 500 ml samples at intervals of 30 or 60 minutes depending on flow conditions	Approx. 80 feet of line with 10 foot vertical lift
IRONDEQUOIT CK AT LANDFILL NARROWS NR ROCHESTER,NY 430958077315600	ISCO Model 1680	Time Mode: Sampler set for two 500 ml samples at intervals of 30 or 60 minutes depending on flow conditions.	Approx. 60 feet of line with 5 foot vertical lift

TABLE 3

MEASURED WETFALL, DRYFALL, AND BULK PRECIPITATION CONCENTRATIONS AND CALCULATED LOADINGS

For CHLORIDE

WETFALL

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.1/	11	5.75	<6.00	0.400	1.30	<4.32	4.04	<4.48	0.447	2.68	<11.6
E. Rochester2/	16	3.07	8.79	6.83	7.35	7.17	2.56	22.8	22.4	7.5	55.3
Mendon Ponds3/	20	.540	.116	.582	1.63	.472	.854	.368	1.30	3.66	6.18

DRYFALL

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.	7	2.55	8.25	1.00	-	5.58	0.794	5.13	0.156	-	6.08
E. Rochester	10	28.0	10.0	3.80	4.70	11.2	8.72	6.23	1.77	.732	17.4
Mendon Ponds	16	.797	.323	.292	3.40	.981	.372	.302	.182	1.59	2.45

BULK COLLECTOR

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Pittsford 4/	9	7.00	10.0	4.63	-	6.32	5.66	9.57	23.5	-	38.8

1/ Period of record July 29, 1980 through October 6, 1981

2/ Period of record June 26, 1980 through October 6, 1981

3/ Period of record October 6, 1980 through September 22, 1981

4/ Period of record July 1, 1980 through November 3, 1981

TABLE 4

MEASURED WETFALL, DRYFALL, AND BULK PRECIPITATION CONCENTRATIONS AND CALCULATED LOADINGS

For TOTAL LEAD

WETFALL

			Measured concentration mg/L					Measured load kg/ha			
Site	No. of samples	Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.1/	3	-	0.011	0.014	-	0.012	-	0.019	0.016	-	0.035
E. Rochester2/	3	-	.010	.007	-	.009	-	.021	.008	-	.029
Mendon Ponds3/	15	.013	.019	.014	.018	.017	.021	.060	.025	.035	.141

DRYFALL

			Measured concentration mg/L					Measured load kg/ha			
Site	No. of samples	Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.	7	-	0.006	0.046	0.042	0.034	-	0.009	0.216	0.129	0.354
E. Rochester	8	-	.060	.028	.063	.049	-	.185	.131	.293	.609
Mendon Ponds	15	.008	.010	.010	.020	.012	.024	.088	.048	.096	.256

BULK COLLECTOR

			Measured concentration mg/L					Measured load kg/ha			
Site	No. of samples	Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Pittsford 4/	5	-	0.017	0.013	-	0.014	-	0.025	0.026	-	0.051

1/ Period of record July 29, 1980 through October 6, 1981

2/ Period of record June 26, 1980 through October 6, 1981

3/ Period of record October 6, 1980 through September 22, 1981

4/ Period of record July 1, 1980 through November 3, 1981

TABLE 5

MEASURED WETFALL, DRYFALL, AND BULK PRECIPITATION CONCENTRATIONS AND CALCULATED LOADINGS

For TOTAL PHOSPHORUS

WETFALL

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.1/	13	0.104	0.024	0.010	0.020	0.041	0.116	0.027	0.011	0.022	0.252
E. Rochester2/	16	.030	.025	.080	.020	.036	.026	.090	.056	.028	.200
Mendon Ponds3/	20	.032	.013	.006	.008	.012	.011	.068	.022	.013	.114

DRYFALL

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.	13	0.115	0.094	0.057	0.025	0.078	0.036	0.088	0.027	0.008	0.158
E. Rochester	15	.198	.188	.058	.047	.126	.062	.176	.036	.021	.295
Mendon Ponds	16	.103	.432	.107	.008	.210	.048	.404	.066	.003	.521

BULK COLLECTOR

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Pittsford 4/	14	0.052	0.359	0.096	-	0.184	0.036	0.141	0.418	-	0.595

1/ Period of record July 29, 1980 through October 6, 1981

2/ Period of record June 26, 1980 through October 6, 1981

3/ Period of record October 6, 1980 through September 22, 1981

4/ Period of record July 1, 1980 through November 3, 1981

TABLE 6

MEASURED WETFALL, DRYFALL, AND BULK PRECIPITATION CONCENTRATIONS AND CALCULATED LOADINGS

For TOTAL KJELDAHL NITROGEN

WETFALL

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.1/	14	1.47	0.621	0.391	0.230	0.821	2.22	3.48	0.436	0.350	6.49
E. Rochester2/	17	1.25	.651	.777	.380	.798	1.27	2.56	1.47	.526	5.83
Mendon Ponds3/	19	.805	.504	.380	.225	.467	.587	2.22	.865	.406	4.08

DRYFALL

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Perinton Sq.	13	1.32	0.842	0.487	0.815	0.829	0.411	0.786	0.228	0.253	1.68
E. Rochester	15	1.15	1.32	.525	.800	.981	.358	1.23	.327	.373	2.29
Mendon Ponds	15	2.20	1.64	.793	.327	1.32	1.03	1.54	.370	.152	3.09

BULK COLLECTOR

Site	No. of samples	Measured concentration mg/L					Measured load kg/ha				
		Spring	Summer	Fall	Winter	Average	Spring	Summer	Fall	Winter	Total
Pittsford 4/	14	1.04	3.74	1.08	-	2.04	1.02	14.9	5.07	-	21.0

1/ Period of record July 29, 1980 through October 6, 1981

2/ Period of record June 26, 1980 through October 6, 1981

3/ Period of record October 6, 1980 through September 22, 1981

4/ Period of record July 1, 1980 through November 3, 1981

TABLE 7

STORM CONCENTRATIONS AND RUNOFF LOADS FOR Blossom Road (Entire watershed upstream of wetlands)

STORM EVENTS			Event Mean Concentrations (mg/liter)								TOTAL RUNOFF LOADS (kg or metric tons*)							
Date	Rainfall (cm)	Runoff (cm)	TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TSS	Total-P	TKN	COD	CL	Pb	Zn	Cd
05-10-81	-	0.759	82	0.14	1.8	25	100	0.020	0.12	0.003	213.	364.	4680.	65.4	260.	51.9	312.	7.81
06-21-81	2.82	.282	282	0.50	3.1	41	81	0.047	0.15	0.003	270.	480.	3000.	39.0	78.1	45.1	144.	2.86
07-02-81	1.42	.117	-	1.50[1/]	3.2	34	93	0.063	1.15	0.002	-	603.	1290.	13.7	37.2	25.3	462.	.817
07-20-81	4.47	.439	-	0.23	2.5	55	58	0.054	0.28	0.004	-	345.	3750.	82.6	87.1	81.0	420.	5.99
07-28-81	2.95	.231	179	0.26	2.2	36	65	0.035	0.13	0.002	142.	206.	1750.	29.0	51.7	27.8	104.	1.59
08-04-81	1.78	.305	237	0.22	1.9	38	57	0.031	0.56	0.013	247.	230.	1980.	39.9	59.9	32.3	584.	13.6
08-10-81	4.22	.414	382	0.23	1.9	47	80	0.065	1.70	0.006	541.	326.	2690.	66.3	113.	92.1	2410.	8.49
Total Sampled Storm Load		2.56									1410.	2550.	19100.	336.	686.	356.	4440.	41.4
SUMMER-FALL BASEFLOW Between storm events		2.47	66	0.16	1.5	20	105	0.01	0.26	0.003	558.	1350.	12700.	169.	888.	84.6	2200.	25.4
WINTER RUNOFF 10-28-80 to 01-24-81		4.01	89	0.38	1.3	-	136	-	-	-	1220.	5220.	17800.	-	1870.	-	-	-
SNOWMELT EVENT 01-25-81 to 03-02-81		7.98	271	0.17	1.6	6	143	0.03	0.86	0.006	7400.	4640.	43700.	164.	3910.	819.	23500.	164.
SPRING RUNOFF 03-03-81 to 05-10-81		4.88	56	0.06	1.3	16	120	0.021	0.86	0.032	934.	1000.	21700.	267.	2000.	350.	14400.	534.
TOTAL SAMPLED LOAD		21.9									11500.	14800.	115000.	936.	9350.	1610.	44500.	765.

1/ Unknown source, between Allen and Linden Avenue gages

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TABLE 8

STORM CONCENTRATIONS AND RUNOFF LOADS FOR Allen Creek (Mixed land-uses)

STORM EVENTS

Date	Rainfall (cm)	Runoff (cm)	Event Mean Concentrations (mg/liter)								TOTAL RUNOFF LOADS (kg or metric tons*)							
			TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TSS*	Total-P	TKN	COD*	CL*	Pb	Zn	Cd
08-05-80	3.56	0.267	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
08-30-80	.711	.064	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
09-01-80	4.39	.490	199	-	-	-	-	-	-	-	65.4	-	-	-	-	-	-	-
09-14-80	2.39	.183	60	-	-	-	-	-	-	-	7.26	-	-	-	-	-	-	-
10-25-80	8.26	1.71	-	0.2	0.7	-	74	0.018	-	0.001	-	227.	795.	-	84.4	20.5	-	1.14
05-10-81	2.29	.343	67	0.13	2.0	32	136	0.023	0.21	0.003	15.4	29.5	456.	7.26	30.9	5.22	47.7	.681
05-15-81	2.41	.429	139	0.17	2.2	34	106	0.035	0.26	0.003	39.9	48.6	628.	9.98	29.9	9.99	74.0	.863
06-21-81	3.22	.366	111	0.23	2.1	-	69	0.087	0.31	0.054	27.2	55.8	510.	-	16.3	21.2	75.4	13.1
07-02-81	1.83	.145	356	0.14	2.7	-	73	0.121	1.80	0.003	34.5	13.6	260.	-	7.26	11.7	173.	.272
07-20-81	5.26	.660	225	0.29	1.9	-	53	0.070	0.18	0.001	99.0	128.	835.	-	23.6	30.8	79.0	.454
07-28-81	3.20	.363	146	0.22	1.9	40	-	0.057	0.13	0.002	35.4	58.1	460.	9.98	-	13.8	31.3	.499
08-04-81	4.90	.714	257	0.31	1.8	51	45	0.066	0.24	0.003	122.	147.	854.	24.5	21.8	31.3	114.	1.41
08-10-81	3.71	.858	240	0.18	1.9	40	36	0.082	0.79	0.006	137.	103.	1050.	22.7	20.9	46.8	451.	3.45
Total Sampled Storm Load		6.58									582.	805.	5890.	74.4	235.	191.	1050.	22.0
SUMMER-FALL BASEFLOW Between storm events		4.88	43	0.14	1.6	16	109	0.017	0.35	0.003	140.	455.	5200.	51.7	354.	55.3	1140.	9.76
WINTER RUNOFF 10-28-80 to 01-24-81		5.59	57	0.08	0.9	-	242	-	-	-	212.	297.	2970.	-	899.	-	-	-
SNOWMELT EVENT 01-25-81 to 03-02-81		10.8	162	0.25	1.9	7	215	0.071	1.05	0.006	1160.	1800.	13700.	49.9	1540.	510.	7550.	43.1
SPRING RUNOFF 03-03-81 to 05-10-81		5.00	22	0.06	1.7	28	190	0.046	0.571	0.063	73.5	200.	5670.	93.5	634.	154.	1910.	210.
TOTAL SAMPLED LOAD		32.8									2170.	3560.	33400.	270.	3660.	910.	11600.	285.

TABLE 9

STORM CONCENTRATIONS AND RUNNOFF LOADS FOR Linden Avenue (Thornell and Thomas Creek basins plus Central basin)

STORM EVENTS

Date	Rainfall (cm)	Runoff (cm)	Event Mean Concentrations (mg/liter) TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TOTAL RUNOFF LOADS (kg or metric ton*) TSS*	Total-P	TKN	COD*	CL*	Pb	Zn	Cd
08-05-80	3.33	0.145	-	-	-	-	38	-	-	-	-	-	-	-	13.6	-	-	-
08-30-80	1.32	.053	-	0.09	0.40	-	91	0.005	-	0.000	-	11.8	53.1	-	11.8	.681	-	.000
09-01-80	6.25	.371	236	0.37	0.80	-	49	0.037	-	0.001	218.	341.	737.	-	45.4	34.1	-	.908
09-14-80	2.36	.135	243	0.27	1.20	-	65	0.025	-	0.001	80.8	89.9	399.	-	21.8	8.31	-	.318
10-25-80	7.32	.701	-	0.23	0.60	-	77	-	0.05	-	-	401.	1050.	-	134.	-	87.2	-
05-10-81	2.18	.290	40	0.11	1.50	30	80	0.012	0.20	0.003	29.0	79.9	1090.	21.8	58.1	8.72	145.	2.18
05-15-81	1.32	.342	57	0.18	1.6	29	87	0.014	0.10	0.003	49.0	153.	1360.	24.5	74.4	11.9	85.4	2.54
06-21-81	2.69	.178	122	0.09	1.7	28	88	0.015	0.15	0.004	53.6	39.5	750.	12.7	39.0	6.63	66.3	1.36
07-02-81	.991	.074	-	0.09	0.20	42	83	0.027	0.37	0.003	-	16.8	37.2	8.17	15.4	4.99	68.6	.545
07-20-81	4.39	.175	285	0.25	2.00	48	59	0.028	0.17	0.005	123.	108.	870.	10.4	25.4	12.2	74.0	2.18
07-28-81	2.67	.173	152	0.22	1.8	34	-	0.021	0.15	0.003	64.4	93.5	765.	14.5	-	8.95	63.6	1.27
08-04-81	2.39	.135	216	0.26	1.8	40	79	0.009	0.78	0.010	72.6	86.7	602.	13.6	26.3	3.00	261.	3.36
08-10-80	4.14	.244	471	0.16	2.5	48	37	0.033	2.98	0.005	285.	96.7	1510.	29.0	22.7	20.0	1800.	3.04
Total Sampled Storm Load		3.02									975.	1520.	9220.	144.	487.	119.	2650.	18.2
SUMMER-FALL BASEFLOW Between storms		4.27	51	0.12	1.1	18	101	0.009	0.39	0.002	542.	1280.	11700.	192.	1070.	95.7	4150.	21.2
WINTER RUNOFF 10-28-80 to 01-24-81		5.18	-	0.08	0.8	-	120	-	-	-	-	1030.	10300.	-	1550.	-	-	-
SNOWMELT EVENT 101-25-81 to 03-02-81		5.69	199	0.24	1.7	5	87	0.015	1.1	0.006	2810.	3390.	24000.	70.8	1230.	212.	15500.	84.8
SPRING RUNOFF 03-0381 to 05-10-81		4.60	9	0.05	1.2	19	97	0.012	0.63	0.029	103.	570.	13700.	217.	1110.	137.	7180.	330.
TOTAL SAMPLED LOAD		22.8									4430.	7790.	68900.	624.	5450.	564.	29500.	454.

TABLE 10

STORM CONCENTRATIONS AND RUNOFF LOADS FOR THOMAS CREEK (Rural headwaters, mixed land uses downstream)

STORM EVENTS																		
Date	Rainfall (cm)	Runoff (cm)	Event Mean Concentrations (mg/liter)								TOTAL RUNOFF LOADS (kg or metric tons*)							
			TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TSS*	Total-P	TKN	COD*	CL*	Pb	Zn	Cd
08-05-80	3.45	0.081	-	0.20	0.60	-	61	0.031	-	0.001	-	11.8	35.4	-	3.63	1.82	-	0.045
08-30-80	1.12	.025	-	0.23	0.70	-	87	0.005	-	0.000	-	4.09	12.2	-	1.82	.091	-	.000
09-01-80	7.06	1.98	75	0.26	0.70	-	44	0.011	-	0.000	10.9	36.8	99.0	-	6.35	1.54	-	.000
09-14-80	2.08	.068	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-25-80	7.67	.376	140	0.50	1.00	-	42	0.041	0.10	0.001	38.1	135.	269.	-	10.9	11.0	26.8	.272
05-10-81	2.39	.165	37	0.11	1.4	30	88	0.031	0.34	0.004	4.54	13.2	165.	3.63	9.98	3.68	40.0	.454
05-15-81	2.18	.221	47	0.18	1.8	31	82	0.016	0.05	0.003	7.26	28.6	285.	4.54	12.7	2.54	7.72	.454
06-21-81	2.89	.117	41	0.11	1.2	23	61	0.013	0.19	0.007	3.63	9.08	101.	1.82	5.45	1.09	15.9	.590
07-02-81	1.14	.117	132	0.15	-	-	88	0.011	0.82	0.002	10.9	12.7	-	-	7.26	.908	69.0	.182
07-20-81	4.34	.140	-	0.21	-	-	-	0.005	1.90	0.004	-	20.9	-	-	-	.499	189.	.409
07-28-81	2,51	.102	27	0.16	1.3	20	65	0.017	0.10	0.008	1.82	11.8	94.0	1.82	4.54	1.22	7.26	.590
08-04-81	2.31	.064	21	0.10	1.2	19	88	0.008	0.14	0.004	.908	4.54	55.4	.908	3.63	.363	6.36	.182
08-10-81	3.05	.175	42	0.14	1.1	35	59	0.34	5.34	0.011	5.45	17.7	138.	4.54	7.26	4.27	669.	1.36
Total Sampled Storm Load		1.85									82.6	305.	1250.	17.2	74.4	29.0	1030.	4.36
SUMMER-FALL BASEFLOW Between storm events		2.67	31	0.12	1.0	14	77	0.005	0.26	0.002	59.0	229.	1910.	26.3	147.	9.53	496.	3.81
WINTER RUNOFF 10-28-80 to 01-24-81		3.56	-	0.09	0.86	-	-	-	-	-	-	229.	2190.	-	-	-	-	-
SNOWMELT EVENT 01-25-81 to 03-02-81		6.25	30	0.13	1.45	4	97	0.031	1.3	0.003	134.	582.	6490.	18.2	434.	139.	5820.	13.4
SPRING RUNOFF 03-03-81 to 05-10-81		3.33	4	0.08	1.2	21	91	0.022	0.94	0.041	9.98	191.	2870.	49.9	218.	52.6	2250.	98.0
TOTAL SAMPLED LOAD		17.6									286.	1540.	14700.	112.	873.	230.	9600.	120.

STORM CONCENTRATIONS AND RUNOFF LOADS FOR THORNELL ROAD (Agricultural/rural)

STORM EVENTS			Event Mean Concentrations (mg/liter)								TOTAL RUNOFF LOADS (kg or metric tons *)							
Date	Rainfall (cm)	Runoff (cm)	TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TSS*	Total-P	TKN	COD*	CL*	Pb	Zn	Cd
08-05-80	1.52	0.094	-	0.26	0.60	-	47	0.019	-	0.001	-	28.1	64.9	-	5.45	2.04	-	0.091
08-30-80	.762	.048	-	0.13	0.40	-	45	0.006	-	0.001	-	7.26	22.2	-	2.72	.318	-	.045
09-01-80	5.49	.241	422	0.40	1.20	-	43	-	-	-	117.	111.	334.	-	11.8	-	-	-
09-14-80	2.62	.130	203	0.21	0.50	-	43	-	-	-	30.9	31.3	74.9	-	6035	-	-	-
10-25-80	7.47	.554	317	0.36	0.60	-	41	-	-	-	202.	229.	382.	-	26.3	-	-	-
05-10-81	2.11	.284	30	0.11	1.30	23	81	0.016	0.22	0.003	9.98	35.9	426.	726.	26.3	-	31.8	-
05-15-81	1.91	.422	66	0.15	1.50	29	69	0.011	0.60	0.003	31.8	72.6	727.	13.6	33.6	5.27	72.2	.999
06-21-81	2.54	.180	99	0.11	1.00	23	56	0.011	0.16	0.006	20.9	22.7	208.	4.54	11.8	5.31	29.0	1.45
07-02-81	1.47	.010	130	0.21	1.7	11	55	0.021	0.72	0.002	1.82	2.27	20.0	0.00	.908	2.27	33.1	2.54
07-20-81	4.14	.173	78	0.18	1.2	29	52	0.009	0.86	0.004	15.4	35.9	239.	5.45	9.99	.227	8.63	.045
07-28-81	2.54	.022	49	0.12	1.1	22	44	0.010	0.06	0.004	7.26	17.2	157.	2.72	6.35	1.77	171.	.817
08-04-81	3.33	.147	117	0.14	1.6	22	10	0.007	0.17	0.029	20.0	23.6	270.	3.63	1.82	1.41	8.63	.590
08-10-81	5.41	.259	129	0.12	1.3	36	53	0.013	3.6	0.007	38.1	35.9	388.	10.9	15.4	1.18	28.6	4.90
																3.90	1080.	2.09
Total Sampled Storm Load		2.67									495.	654.	3310.	49.9	159.	23.7	1460.	12.3
SUMMER-FALL BASEFLOW Between storms		5.51	45	0.06	0.6	12	48	0.006	0.09	0.002	285.	380.	3800.	76.2	304.	38.0	570.	12.7
WINTER RUNOFF 10-28-80 to 01-24-81		2.49	50	0.06	0.7	-	53	-	-	-	2270.	378.	4410.	-	334.	-	-	-
SNOWMELT EVENT 01-25-81 to 03-02-81		5.74	344	0.26	1.9	4	47	0.011	0.9	0.007	42.7	1700.	12600.	26.3	310.	72.6	5950.	46.3
SPRING RUNOFF 03-03-81 to 05-10-81		5.31	7	0.04	0.8	10	55	0.009	0.52	0.026	3410.	244.	4900.	60.8	335.	54.9	3170.	158.
TOTAL SAMPLED LOAD		24.7									6500.	3400.	29000.	213.	1440.	189.	11200.	229.

TABLE 11

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TABLE 12

STORM CONCENTRATIONS AND RUNNOFF LOADS FOR East Rochester (High density residential)

STORM EVENTS

			Event Mean Concentrations (mg/liter)								TOTAL RUNOFF LOADS (kg)							
Date	Rainfall (cm)	Runoff (cm)	TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TSS	Total-P	TKN	COD	CL	Pb	Zn	Cd
10-25-80	7.77	1.37	-	0.24	0.6	-	15	0.06	0.07	0.002	-	4.58	11.5	-	288.	1.15	1.36	0.038
05-10-81	2.21	.909	28	0.23	1.3	69	58	0.04	0.40	0.002	356.	2.90	16.5	878.	738.	.508	5.08	.025
05-15-81	2.08	.531	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06-21-81	2.67	.663	228	0.35	3.1	67	16	0.22	0.38	0.005	2120.	3.27	28.7	622.	148.	2.04	3.54	.046
07-02-81	1.52	.175	270	0.76	4.4	129	18	0.34	1.33	0.004	664.	1.86	10.8	317.	44.5	.835	3.27	.010
07-20-81	4.14	.940	275	0.42	1.6	58	9	0.13	0.20	0.002	3630.	5.54	21.1	763.	118.	1.71	2.63	.026
07-28-81	2.97	.333	191	0.73	1.7	60	12	0.13	0.23	0.003	886.	3.40	7.90	316.	55.8	.604	1.04	.014
08-04-81	2.01	-	260	0.35	3.8	110	10	0.19	0.26	0.002	1400.	1.86	20.4	591.	53.6	1.02	1.41	.011
08-10-81	2.87	.213	470	0.46	5.6	97	-	0.32	0.78	0.003	3180.	3.09	37.9	656.	-	2.16	5.27	.020
Total Sampled Storm Load		5.13									12200.	26.3	155.	4140.	1450.	9.99	23.6	.181

SUMMER-FALL BASEFLOW

Between storms

No data recorded

WINTER RUNOFF

No data recorded

SNOWMELT EVENT

No data recorded

SPRING RUNOFF

No data recorded

TOTAL SAMPLED LOAD

TABLE 13

STORM CONCENTRATIONS AND RUNOFF LOADS FOR Cranston Road (Moderate density residential)

STORM EVENTS

Date	Rainfall (cm)	Runoff (cm)	Event Mean Concentrations (mg/liter) TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TOTAL RUNOFF LOADS (kg) TSS	Total-P	TKN	COD	CL	Pb	Zn	Cd
08-05-80	1.96	0.244	-	0.28	0.90	-	12	0.059	-	0.001	-	0.454	1.50	-	19.5	0.095	-	0.002
08-30-80	1.98	0.200	-	0.52	2.00	-	36	0.064	-	0.001	-	.681	2.68	-	48.6	.086	-	.001
09-01-80	7.04	1.21	101	0.50	0.80	-	27	0.017	-	0.002	825.	4.09	6.54	-	221.	.141	-	.016
09-14-80	1.98	0.279	43	0.12	0.60	-	17	0.013	-	0.001	81.7	.227	1.14	-	32.2	.023	-	.002
10-25-80	7.47	2.05	-	0.35	0.80	-	22	0.011	0.07	0.000	-	4.81	11.	-	303.	.150	.953	.000
05-10-81	2.31	0.574	319	0.22	1.70	60	40	0.066	0.47	0.003	1230.	.863	6.58	232.	154.	.254	1.82	.012
05-15-81	1.73	0.348	59	0.17	1.50	39	31	0.026	0.25	0.003	138.	.409	3.50	91.2	72.6	.059	.590	.007
06-21-81	2.51	0.462	67	0.14	1.30	26	35	0.022	0.23	0.009	208.	.454	4.04	80.8	109.	.068	.726	.028
07-02-81	1.48	0.147	173	0.49	2.10	24	14	0.040	0.73	0.003	172.	.499	2.09	23.6	14.1	.041	.726	.003
07-20-81	4.17	0.729	101	0.33	1.40	32	14	0.460	0.68	0.006	495	1.63	6.86	157.	68.6	.227	3.31	.030
07-28-81	2.51	0.340	12	0.15	1.90	18	13	0.009	0.23	0.003	27.2	.363	4.36	41.3	29.5	.023	.545	.007
08-04-81	3.81	0.500	145	0.35	1.90	45	11	0.021	0.21	0.003	489.	1.18	6.40	152.	37.2	.073	.726	.010
08-10-81	3.68	0.648	169	0.23	2.20	20	-	0.038	0.61	0.003	736.	.999	9.58	87.2	-	.163	2.86	.013
Total Sampled Storm Load		7.72									4410.	16.8	66.3	864.	1110.	1.54	11.9	.131
SUMMER-FALL BASEFLOW Between storms	-	4.91	79	0.22	2.40	30	175	0.220	0.38	0.002	2610.	7.26	79.4	993.	5790.	.726	12.6	.066
WINTER RUNOFF 10-28-80 to 01-24-81	-	5.38	45	0.17	1.10	-	160	-	-	-	1630.	6.17	39.8	-	5790.	-	-	-
SNOWMELT EVENT 01-25-81 to 03-02-81	-	7.06	73	0.25	1.60	-	170	0.052	2.90	0.012	3470.	11.9	76.0	-	8080.	2.47	13.8	.570
SPRING RUNOFF 03-03-81 to 05-10-81	-	4.07	170	0.22	2.90	82	62	0.059	0.93	0.013	4650.	6.04	79.4	2240.	1700.	1.62	25.2	.356
TOTAL SAMPLED LOAD		29.2									16800.	48.2	341.	4100.	2247.	6.36	188.	1.12

TABLE 14

STORM CONCENTRATIONS AND RUNOFF LOADS FOR SOUTHGATE ROAD-(Commerical/residential site)

STORM EVENTS			Event Mean Concentrations (mg/liter)								TOTAL RUNOFF LOADS (kg)							
Date	Rainfall (cm)	Runoff (cm)	TSS	Total P	TKN	COD	CL	Pb	Zn	Cd	TSS	Total-P	TKN	COD	CL	Pb	Zn	Cd
08-05-80	3.63	0.670	-	-	1.3	-	45	0.151	-	0.005	-	-	6.31	-	219.	.735	-	0.024
08-30-80	1.45	.206	82	0.26	1.1	-	68	0.032	-	0.001	123.	.409	1.63	-	102.	.050	-	.001
09-01-80	7.11	1.40	695	0.24	0.5	-	36	0.043	-	0.001	7060.	2.45	5.08	-	365.	.436	-	.010
09-14-80	1.91	.340	107	0.16	0.6	-	48	0.036	-	0.000	263.	.409	1.50	-	118.	.091	-	.000
10-25-80	7.82	1.95	96	0.32	0.7	32	27	0.036	0.07	0.001	1360.	4.54	9.90	453.	382.	.508	2.92	.014
05-10-81	2.29	.592	61	0.15	1.7	46	115	0.050	0.36	0.002	262.	.636	7.31	198.	494.	.213	3.82	.009
05-15-81	1.68	.699	118	0.26	2.1	66	80	0.039	0.19	0.003	597.	1.32	10.6	334.	405.	.195	2.36	.015
06-21-81	3.05	.551	142	0.21	1.5	50	61	0.031	0.22	0.011	566.	.817	6.00	199.	243.	.122	2.14	.044
07-02-81	.889	.145	110	0.23	1.9	46	58	0.057	1.79	0.003	115.	.227	2.00	48.1	60.8	.059	4.61	.003
07-20-81	4.29	.787	100	0.23	1.3	24	43	0.035	2.16	0.005	571.	1.32	7.44	137.	246.	.200	12.3	.029
07-28-81	2.49	.516	43	0.17	1.1	26	50	0.020	0.39	0.003	161.	.636	4.09	97.2	187.	.073	1.45	.011
08-04-81	2.64	.523	160	0.21	1.2	35	42	0.036	0.27	0.003	606.	.817	4.54	132.	159.	.136	1.04	.011
08-10-81	4.06	.808	89	0.14	1.1	32	15	0.052	6.18	0.005	521.	.817	6.45	188.	87.6	.449	36.2	.029
Total Sampled Storm Load		9.19									12200.	14.3	72.6	1790.	3070.	3.32	57.6	.201
SUMMER-FALL BASEFLOW Between storms		5.44	107	0.19	1.5	36	190	0.054	0.26	0.002	4210.	7.49	59.0	1420.	7500.	2.12	10.2	.078
WINTER RUNOFF 10-28-80 to 01-24-81		5.18	99	0.12	1.1	-	307	-	-	-	3720.	4.49	41.4	-	11500.	-	-	-
SNOWMELT EVENT 01-25-81 to 03-02-81		10.3	94	0.20	1.4	125	298	0.05	0.64	0.003	7050.	15.0	105.	9400.	22300.	3.75	48.4	.225
SPRING RUNOFF 03-03-81 to 05-10-81		7.92	270	0.26	2.3	71	160	0.092	0.98	0.052	15500.	14.9	132.	4080.	9200.	5.28	56.2	2.99
TOTAL SAMPLED LOAD		38.0									42700.	56.2	410.	16700.	53600.	14.5	172.	3.49

APPENDIX B

COSTS FOR CONTROL MEASURES

Use of the Wetlands:

Costs -

1. Structure at the Narrows

Capital Costs -

Corrugated Metal Pipe (outlet structure) 10 ft diameter, materials and installation 82 ft x $300/ft	= $	24,600
Fill material, compaction, miscellaneous excavation 2600 cy x $6/cy	= $	15,600
Rip-rap (dumped stone) placed on upstream side of embankment and at outlet to CMP 500 sy x $40/sy	= $	20,000
Berm protection (topsoil & seeding) 160 xy x $5/sy	= $	800
Inflatable dam (total installation)	= $	125,000

O & M

27% of capital cost (includes routine O&M & additional cost for dredging)	= $	50,300
Annual Cost = $186,000 x 0.102 + $50,300	= $	69,300

2. Structure at Empire Boulevard

Assume present roadway embankment is essentially adequate but side slope on upstream side must be made less steep and slope protection must be provided. Assume that present side slope is 1 on 2 and 10 ft. high.

Capital Cost -

Roadway improvements

1000 lf x $1500/lf = $ 1,500,000
(includes grouted rip-rap, extra embankment and bridge over outlet structure)

Outlet Structure = $ 500,000

O & M Cost

6% of capital cost
0.06 x $2,000,000 = $ 120,000

Annual Cost = $2,000,000 x 0.102 + $120,000 = $ 324,000

In-Stream Impoundments: Costs

1. Reservoir No. 2 -

Assume land acquisition costs = $2000/ac and total land area required = 36 ac

Costs -

Capital

Land 36 ac x $2000/ac	= $	72,000
Outlet Structure	= $	250,000
Berm (gabion type) 2200 sy x $60/sy	= $	132,000
Shoreline protection 600 cy x $20/cy	= $	12,000

O & M

Capital costs (excluding land) x 0.12 394,000 x 0.12	= $	47,280
Annual Cost = $466,000 x 0.102 + $47,280	= $	94,812

0.102 = Capital Recovery Factor (8%, 20 yr.)

2. Reservoir No. 4 - Spring Lake Park

Because land is already developed (as opposed to Reservoir No. 2), assume land acquisition costs of $5000/ac. Required area is approximately 77 ac.

Costs -

Capital

Land Acquisition 77 ac x $5000/ac = $ 385,000

Outlet Structure w/berm = $ 250,000

O & M

12% of capital cost (excluding land)
$250,000 x 0.12 = $ 30,000

Annual Cost = $635,000 x 0.102 + $30,000 = $ 94,770

where 0.102 = Capital Recovery Factor (8%, 20 yr.)

3. Reservoir No. 6 - (Bushnell's Basin) Barge Canal

Assume land acquisition costs at $2000/ac
Total area required = 110 ac

Costs -

Capital

Land acquisition 110 ac x $4000/ac = $ 440,000

Outlet Structure = $ 250,000

Roadway improvements (used as berm)
300 lf x $300/lf = $ 90,000

O & M

12% of capital cost (excluding land)
$340,000 x 0.12 = $ 40,800

Annual Cost = $780,000 x 0.102 + $40,800 = $ 120,360

where 0.102 = Capital Recovery Factor (8%, 20 yr.)

Stormwater Infiltration

Costs	Capital Cost	O & M Cost	Number Req'd
Inlet Structure	$10,000	$1,200	1263
Swirl Concentrator	$12,000	$1,000	632

Interest Rate: 8% per annum

Service Life: 20 years (amortization period)

Capital Recovery Factor: (8%, 20 yr.) = 0.102

Therefore, annual costs are as follows:

Without swirls - $10,000 x 1263 x 0.102 + $1200 x $1263 = $2.804 million

With swirls - $12,000 x 632 x 0.102 + $1000 x 632
+ $2,804 million = $ 4.210 million

APPENDIX C

EXAMPLE OF AN EROSION AND SEDIMENT ORDINANCE

MODEL ORDINANCE

EROSION AND SEDIMENT CONTROL

by

ASSOCIATION OF BAY AREA GOVERNMENTS

(Reprinted with permission)

THE MODEL ORDINANCE AS PRESENTED HEREIN IS INTENDED TO SERVE ONLY AS AN EXAMPLE OF ONE THAT HAS BEEN SUCCESSFULLY IMPLEMENTED.

Monroe County or local municipalities within the Irondequoit Bay watershed could use this ordinance as a guide in formulating one that addresses local concerns and needs. Since this ordinance was written for the San Francisco, California area, there are references to climatological factors that would be totally different for the Rochester, New York area. In addition, passages or blanks enclosed in brackets are intended to be filled in by local jurisdictions.

Article I

Title, Purpose and General Provisions

101.00 Title. This ordinance shall be known as the "[City/County] Erosion and Sediment Control Ordinance" and may be so cited.

101.00 Purpose. The purpose of this Chapter is to promote and protect the public interest by regulating land disturbances, land fill and soil storage in connection with the clearing and grading of land for construction. The intent of this ordinance is to establish administrative procedures, minimum standards of review and implementation and enforcement procedures for the protection and enhancement of the water quality of watercourses, water bodies and wetlands, natural and man-made, by controlling erosion, sedimentation, increases in surface runoff and related environmental damage caused by construction-related activities.

101.02 Definitions. When used in this Chapter, the following words shall have the meanings ascribed to them in this Section:

(a) Administrator: the Director of [ ] and duly authorized agents and employees of [ ].

(b) Applicant: any person, corporation, partnership, association of any type, public agency or any other legal entity who submits an application to the Administrator for a permit pursuant to this Chapter.

(c) Best Management Practice (BMP): a technique or series of techniques which, when utilized in a designated manner, is proven to be effective in controlling construction-related runoff, erosion and sedimentation (see §101.02(j)).

(d) Chapter: this ordinance in its entirety.

(e) Erosion: the action or process of wearing away of earth or soil by the action of water.

(f) Final Erosion and Sediment Control Plan: a set of measures designed to control surface runoff and erosion and to retain sediment on a particular site after all other planned final structures and permanent improvements have been erected or installed.

(g) Interim Erosion and Sediment Control Plan: a set of measures designed to control surface runoff and erosion and to retain sediment on a particular site during the period in which pre-construction and construction-related land disturbances, fills and soil storage occur.

(h) Land disturbance/land disturbing activities: any human activity moving or removing the soil mantle or top 6 inches of soil whichever is shallower.

(i) Land fill: any human activity depositing soil or other earth materials.

(j) Manual of Standards (Manual): a compilation of technical application standards and design specifications adopted by the Administrator as being proven methods of controlling construction-related surface runoff, erosion and sedimentation (see §101.02(c)).

(k) Permittee: the applicant in whose name a valid permit is duly issued pursuant to this Chapter and his/her/its agents, employees and others acting under his/her/its direction.

(l) Sediment: material deposited by water.

(m) Site: a parcel or parcels of real property owned by one or more than one person which is being or is capable of being developed as a single project.

(n) Wet season: the period from [October 15 to April 15].

(o) Watercourse: [to be defined and designated by the local jurisdiction].

101.03 Severability and Validity. If any part of this ordinance is found not valid, the remainder of this ordinance shall remain in effect.

101.04 Nuisance Abatement. Neither this Chapter, nor any administrative ruling made under it, limits:

(a) The power of the [City/County] to declare, prohibit and abate a nuisance; or

(b) The right of any person to maintain, at any time, any appropriate action for relief against any private nuisance, or for relief against any contamination or pollution.

Article II

Permit Application Procedures

201.01 Scope. No person may grade, fill, excavate, store or dispose of soil and earthen materials or perform any other land-disturbing or land-filling activity without first obtaining a Permit as set forth in this Chapter.

201.02 Exemptions. All land-disturbing or land-filling activities or soil storage shall be undertaken in a manner designed to minimize surface runoff, erosion and sedimentation.

(a) General Exemptions: A person performing such activities need not apply for a Permit pursuant to this Chapter, if all the following criteria are met:

(1) The land area disturbed or filled is 1/4 acre or less;

(2) Natural and finished slopes are less than 10%;

(3) Volume of soil or earth materials stored is 50 cubic yards or less;

(4) Rainwater runoff is diverted, either during or after construction, by the activities from an area smaller than 5,000 square feet;

(5) An impervious surface, if any, of less than 5,000 square feet is created;

(6) No drainageway is blocked or has its stormwater carrying capacities or characteristics modified;

(7) No land-disturbing or filling activities occur within 100 feet of a watercourse.

(b) Specific Exemptions: Section (a) notwithstanding, a person performing the following activities need not apply for a Permit pursuant to this Chapter:

(1) Routine agricultural crop management practices;

(2) Work to correct or remedy emergencies posing an immediate danger to life or property, or substantial flood or fire hazards.

202.00 Application. The application for a Permit must include all of the following items:

(a) Application form;

(b) Site Map and Grading Plan;

(c) Interim Erosion and Sediment Control Plan;

(d) Final Erosion and Sediment Control Plan, where required (see §301.07);

(e) Soils and Geological Reconnaissance Report, where required (see §301.05);

(f) Work schedule;

(g) Application fees;

(h) Performance bond or other acceptable security (see §202.07);

(i) Any supplementary material required by the Administrator.

202.01 Application Form. The following information is required on the application form:

(a) Name, address and telephone number of the Applicant;

(b) Names, addresses and telephone numbers of any and all contractors, subcontractors or persons actually doing the land-disturbing activity and their respective tasks;

(c) Name(s), address(es) and telephone number(s) of the person(s) responsible for the preparation of the Site Map and Grading Plan;

(d) Name(s), address(es) and telephone number(s) of the person(s) responsible for the preparation of the Interim and/or Final Erosion and Sediment Control Plan;

(e) Name, address and telephone number of the registered [Geologist] responsible for the preparation of the Soils and Geological Reconnaissance Report, where required (see §301.05);

(f) A vicinity map showing the location of the site in relationship to the surrounding area's watercourses, water bodies and other significant geographic features, and roads and other significant structures;

(g) Date of the application;

(h) Signature(s) of the owner(s) of the site or of an authorized representative.

202.02 Site Map and Grading Plan. The Site Map and Grading Plan shall contain all the following information:

(a) Existing and proposed topography of the site taken at not more than a [x-foot] contour interval over the entire site. Ninety percent (90%) of the contours shall be plotted within one contour interval of the true location;

(b) Two contour intervals that extend a minimum of [100 feet off-site, or sufficient to show on- and off-site drainage];

(c) Site's property lines shown in true location with respect to the plan's topographic information;

(d) Location and graphic representation of all existing and proposed natural and man-made drainage facilities;

(e) Location and graphic representation of proposed excavations and fills, of on-site storage of soil and other earthen material, and of on-site disposal;

(f) Location of existing vegetation types and the location and type of vegetation to be left undisturbed;

(g) Location of surface runoff, erosion and sediment control measures as required under §202.03(d);

(h) Quantity of soil or earthen materials in tons and cubic yards to be excavated, filled, stored or otherwise utilized on-site;

(i) Outline of the methods to be used in clearing vegetation, and in storing and disposing of the cleared vegetative matter;

(j) Proposed sequence and schedule of excavation, filling and other land-disturbing and filling activities, and soil or earthen material storage and disposal.

202.03 Interim Erosion and Sediment Control Plan (Interim Plan). All the following information shall be provided with respect to conditions existing on the site during land-disturbing or filling activities or soil storage:

(a) Maximum surface runoff from the site shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(b) Sediment yield shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(c) The Interim Plan shall also contain the following information:

  (1) a delineation and brief description of the measures to be undertaken to retain sediment on the site, including, but not limited to, the designs and specifications for berms and sediment detention basins, and a schedule for their maintenance and upkeep,

  (2) a delineation and brief description of the surface runoff and erosion control measures to be implemented, including, but not limited to, types and method of applying mulches, and designs and specifications for diverters, dikes and drains, and a schedule for their maintenance and upkeep,

  (3) a delineation and brief description of the vegetative measures to be taken, including, but not limited to, seeding methods, the type, location and extent of pre-existing and undisturbed vegetation types, and a schedule for maintenance and upkeep;

(d) The location of all the measures listed by the Applicant under Subsection (c) above, shall be depicted on the Site Map and Grading Plan (see §202.02 (f)-(g));

(e) An estimate of the cost of implementing and maintaining all interim erosion and sediment control measures must be submitted in a form acceptable to the Administrator.

202.04 Final Erosion and Sediment Control Plan (Final Plan). All the following information shall be provided with respect to conditions existing on the site after final structures and improvements (except those required under this Section) have been completed and where these final structures have not been covered by an Interim Plan, (see §301.07):

(a) Maximum runoff from the site shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(b) Sediment yield shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(c) The Final Plan shall also contain the following information:

  (1) a description of and specifications for sediment retention devices,

  (2) a description of and specifications for surface runoff and erosion control devices,

  (3) a description of vegetative measures,

  (4) a graphic representation of the location of all items in Subsections (1)-(3) above;

(d) An estimate of the costs of implementing all final erosion and sediment control measures must be submitted in a form acceptable to the Administrator.

202.05 Soils and Geological Reconnaissance Report (Soils Report). A Soils Report, when required by the Administrator (see §301.05), shall be based on adequate test borings, as necessary, and shall contain all the following information:

(a) Data regarding the nature, distribution and erodibility of existing soils;

(b) Data regarding the nature, distribution and erodibility of soil to be placed on the site, if any;

(c) Conclusions and recommendations for grading procedures;

(d) Conclusions and recommended designs for interim soil stabilization devices and measures and for permanent soil stabilization after construction is completed.

202.06 Work Schedule. The Applicant must submit a master work schedule showing the following information:

(a) Proposed grading schedule;

(b) Proposed conditions of the site on each [July 15, August 15, September 15, October 1 and October 15] during which the Permit is in effect;

(c) Proposed schedule for installation of all interim erosion and sediment control measures including, but not limited to, the stage of completion of erosion and sediment control devices and vegetative measures on each of the dates set forth in Subsection (b);

(d) Schedule for construction, if any;

(e) Schedule for installation of permanent erosion and sediment control devices where required (see §301.07).

202.07 Security

(a) The Applicant shall provide security for the performance of the work described and delineated on the approved Grading Plan in an amount to be set by the Administrator [but not to exceed 100%] of the approved estimated cost of the grading. The form of security shall be one or a combination of the following to be determined by the Administrator:

(1) bond or bonds issued by one or more duly authorized corporate sureties. The form of the bond or bonds shall be subject to the approval of the [City Attorney/County Counsel],

(2) deposit, either with the city or a responsible escrow agent or trust company at the option of the [City/County], of money, negotiable bonds of the kind approved for securing deposits of public monies, or other instrument of credit from one or more financial institutions subject to regulation by the State or Federal government wherein said financial institution pledges funds are on deposit and guaranteed for payment.

(b) The Applicant shall provide security for the performance of the work described and delineated in the Interim Plan in an amount to be determined by the Administrator but not less than 100% of the approved estimated cost of performing said work. The form of the security shall be as set forth in Subsections (a)(1) and (2).

(c) The Applicant shall provide security for the performance of the work described and delineated in the Final Plan in an amount to be determined by the Administrator but not less than 100% of the approved estimated cost of performing said work. The form of the security shall be as set forth in Subsections (a)(1) and (2).

203.01 Fees. The following fees are to be paid pursuant to a schedule of fees adopted, and amended from time to time by the [City Council/Board of Supervisors] upon recommendation by the Administrator:

(a) A permit processing fee, to be paid at the time the permit application is submitted;

(b) An inspection fee to be paid at the completion of the work described in the Interim Plan;

(c) An inspection fee to be paid at the completion of the work described in the Final Plan;

(d) The Administrator may at his option require partial payment of the fees set forth in Subsections (b) and (c) of this Section before issuing a permit.

204.01 Decision on a Permit. The Administrator shall review all documents submitted pursuant to this Chapter and, if necessary, request additional data, clarification of submitted data or correction of defective submissions within 10 working days after the date of submission. The Administrator shall notify Applicant of his decision on the permit within 20 working days of the initial submission or of the corrected submissions, whichever is later.

204.02 Permit Issuance. Approval of an application by the Administrator shall be issued, if at all, within [3] working days.

204.03 Permit Duration. Permits issued under this Chapter shall be valid for the period during which the proposed land-disturbing or filling activities and soil storage takes place or is scheduled to take place, whichever is shorter. Permittee shall commence permitted activities within 60 days of the scheduled commencement date for grading or the Permitee shall resubmit all required application forms, maps, Plans, schedules and security to the Administrator. The Administrator may require additional fees.

204.04 Permit Denial. The Applicant may request a hearing before the [City Council/Board of Supervisors] within [5] working days of notification of a permit denial. The hearing shall be held within [15] working days.

204.05 Assignment of Permit. A Permit issued pursuant to this Chapter may be assigned, provided:

(a) The Permittee notifies the Administrator of the proposed assignment;

(b) The proposed assignee:

  (1) submits an application form pursuant to §202.01, and

  (2) agrees in writing to all the conditions and duties imposed by the Permit, and

  (3) agrees in writing to assume responsibility for all work performed prior to the assignment, and

  (4) provides security pursuant to §202.07, and

  (5) agrees to pay all applicable fees pursuant to §203.01;

(c) The Administrator approves the assignment.

The Administrator shall set forth in writing the reasons for his/her approval or disapproval of an assignment.

Article III

Review Standards and Procedures

301.01 Review Policy. The Administrator shall issue a Permit provided he/she finds that the plans submitted in application for a Permit individually and in the aggregate:

- (a) Protect the quality of receiving waters;
- (b) Minimize surface runoff, erosion and off-site sedimentation:
  - (1) to the extent feasible, or
  - (2) in the case where the work site is situated in a §201.02(a)(7) area, to the extent possible.

301.02 Site Map and Grading Plan. Before approving the Site Map and Grading Plan, the Administrator shall find as required by §301.01.

- (a) The review process shall include, but is not limited to, examination of the Site Map and Grading Plan for:
  - (1) adherence to the requirements set forth in §202.02,
  - (2) signature(s) by a [Civil Engineer, or other qualified persons],
  - (3) internal coherence.
- (b) Where the Site Map and Grading Plan cannot be approved as submitted, the Administrator may require the Applicant to adopt one or all of the following measures:
  - (1) reduce the area of land to be disturbed,
  - (2) restrict land-disturbing or filling activities or soil storage to the dry season (see also §402.01(c)),
  - (3) revise and resubmit Site Map and Grading Plan.
- (c) The Site Map and Grading Plan, if approved, either as submitted or as modified under Subsection (b), is part of the Permit.

301.03 Interim Plan. Before approving the Interim Plan, the Administrator shall find as required by §301.01.

(a) The Applicant may propose the use of any erosion and sediment control techniques in the Interim Plan provided such techniques are proven to be as or more effective than the equivalent BMP contained in the Manual.

(b) The review process shall include, but is not limited to, examination of each proposed technique, individually or in the aggregate, for:

(1) suitability to and effectiveness under the anticipated conditions at the work site both at the onset of and throughout the wet season,

(2) location(s) on the work site,

(3) size(s), carrying or holding capacity(ies) and design(s) for controlling the predicted surface runoff and sediment yield,

(4) allotted time(s) for full installation and implementation,

(5) sequencing, both among themselves and in concert with land-disturbing activities, especially when land-disturbing and filling activities and soil storage will commence either at the onset of or during the wet season,

(6) proposed maintenance method(s) and schedule(s).

(c) The Administrator shall require the Applicant to change the proposed technique or BMP, or any facet thereof, where he/she deems necessary.

(d) The Interim Plan, as approved or as modified under §402.02(a), is a part of the Permit.

301.04 Final Plan. Before approving the Final Plan, the Administrator shall find as required under §301.01.

(a) The Applicant may propose the use of any erosion and sediment control techniques in the Final Plan provided such techniques are proven to be as or more effective than the equivalent BMP contained in the Manual.

(b) The review process shall include, but is not limited to, examination of each proposed technique, individually and in the aggregate, for:

(1) suitability to and effectiveness under the anticipated conditions at the work site throughout the period during which the Final Plan is to be implemented and in effect,

(2) location(s) on the work site,

(3) adequacy of the proposed size(s), carrying and holding capacity(ies) and design(s) for controlling the predicted surface runoff and sediment yield,

(4) allotted time(s) for full installation and implementation,

(5) proposed maintenance method(s) and schedule(s).

(c) The Administrator shall require the Applicant to change the proposed technique or BMP, or any facet thereof, where he/she deems necessary.

(d) The Final Plan, as approved or as modified under §402.02(a), is a part of the Permit.

301.05 Soils Report. A Soils Report meeting the criteria set forth in §202.05 shall be required for all Major Permits. A Soils Report shall also be required for a Minor Permit unless the Administrator determines that all of the following apply:

(a) The soil type for the region in which the work site is situated is recorded in the Manual, an official survey by local state or federal agencies or other widely recognized authority in the field of [ ];

(b) The soil type, as recorded, is sufficiently precise to be utilized in the equations, referenced in §§202.03(b) and 202.04(b);

(c) The soil on the work site is representative of the region surveyed by the literature of Subsection (a);

(d) The site is not in a §201.02(a)(7) area.

301.06 Work Schedule. The Administator shall review the work schedule for overall coherence. Any modifications to the Site Map and Grading Plan, Interim Plan and Final Plan shall be noted on the work schedule and the schedule modified, as necessary.

301.07 Coordination with Other Permits. Where a person applies to the Administrator for a Permit pursuant to this Chapter and either does not apply for the necessary permits to make improvements on the same site or applies for the permits necessary to make only a portion of the prospective improvements on the same site, the Applicant need not submit a Final Plan for the site or those portions of the site wherein Applicant does not plan to make improvements, and this Section shall apply.

(a) The Interim Plan shall be adequate to control surface runoff and sedimentation from the unimproved areas of the site for the period of time between termination of the Permit and implementation of a Final Plan, pursuant to Subsection (c) of this Section.

(b) The security for the Interim Plan shall be retained until a Final Plan(s) has been implemented. The security may be released on a pro rata basis where a Final Plan or series of Final Plans is/are implemented for a portion or portions of the site.

(c) No [building permit, permit of occupancy, etc.] shall be issued until the Applicant for such a permit has presented to the permitting agency certification from the Administrator that:

(1) a Final Plan has been filed with and approved by the Administrator pursuant to this Chapter,

(2) security for the Final Plan has been posted in accordance with §202.07(c),

(3) Applicant presenting such certification has agreed in writing to implement the Final Plan pursuant to the requirements and enforcement procedures of this Chapter,

(4) Applicant has paid all pertinent fees.

Article IV

Implementation and Enforcement

401.01 Minor Permit.

(a) The Administrator shall issue a Minor Permit only if:

(1) total area of disturbed or filled land is [1/4] acre or less, and the natural and/or finished slopes are greater than 10%, and are also 15%, or less, or

(2) rainwater runoff is diverted from a total area of [1/4] acre or less, or a total area of [1/4] acre or less is made impervious, and the natural and/or finished slopes are greater than 10% and are also 15% or less, or

(3) total area of disturbed or filled land is [3/4] acre or less and greater than [1/4], and the natural and/or finished slopes are 15%, or less, or

(4) rainwater runoff is diverted from a total area of [3/4] acre or less and the natural and/or finished slopes are 15%, or less, or

(5) total area of disturbed or filled land is greater than [3/4] acre but less than [5] acres, and the natural and finished slopes are 2%, or less, or

(6) rainwater runoff is diverted from a total area greater than [3/4] acre but less than [5] acres, and the natural and/or finished slopes are 2%.

Provided, in all of the situations defined in (a)(1)-(6), above:

(7) total volume of stored soil is [1,200 cubic yards] or less, and

(8) none of the activity is in a §201.02(a)(7) area.

(b) The Minor Permit is issued subject only to the conditions set forth in §401.03.

(c) The Administrator shall enforce a Minor Permit only through the procedures set forth in §403.01, or by inspections at the discretion of the Administrator, or by any other means available at law or in equity.

401.02 Major Permit.

(a) All permits other than Minor Permits issued under this Chapter are Major Permits.

(b) The Major Permit is issued subject to the conditions set forth in §§401.03 and 402.01-02.

(c) The Administrator shall enforce a Major Permit through any procedures set forth in this Article or by any other means available at law or in equity.

401.03 Issuance of Major and Minor Permits. Administrator shall issue a Major or Minor Permit upon approval of a Site Map and Grading Plan, Interim Plan, Final Plan, where required (see §301.07), Soil Report, where required (see §301.05), deposit of appropriate security and payment of fees. The Major and Minor Permits shall be issued subject to the following conditions:

(a) The Permittee shall maintain a copy of the Permit, approved plans and, for Major Permits only, reports required under §402.01, on the work site and available for public inspection during all working hours;

(b) The Permittee shall, at all times, be in conformity with approved Site Map and Grading Plan, Interim and Final Plans.

402.01 Implementation of Major Permits--Permittee's Duties. In addition to performing as required under §401.03, Permittee shall:

(a) Notify the Administrator, at least forty-eight (48) hours beforehand, of the beginning of land-disturbing or filling activities or soil storage;

(b) Submit to the Administrator, reports on:

(1) the progress of or delays in land-disturbing or filling activities or soil storage,

(2) any other departures from the approved Site Map and Grading Plan which may affect implementation of the Interim or Final Plans as scheduled,

(3) possible delays in obtaining materials, machinery, services or manpower necessary to the implementation of the Interim or Final Plans as scheduled,

(4) the progress of or delays in the implementation of the Interim or Final Plans,

(5) any other departures from implementation of the Interim or Final Plans,

(6) according to the schedule set forth below:

  (i) for the period from [April 15] to July 31, monthly;

  (ii) for the period from August 1 to September 30, weekly;

  (iii) for the period from October 1 to October 15, twice a week;

  (iv) for the period from [October 16 to April 14], weekly;

(c) When Permittee proposes to commence land-disturbing or filling activities or soil storage during the wet season, Permittee shall demonstrate that land disturbance is relatively minor and that erosion can be easily controlled, or is a necessary and integral part of an Interim Plan for previously-initiated project phases. Where such activities are approved, Permittee shall submit:

(1) a report seventy-two (72) hours prior to and, again, at the start of land-disturbing or filling activities or soil storage,

(2) a report seventy-two (72) hours prior to and, again, at the start of implementing the Interim Plan,

(3) a report upon completion of the Interim Plan,

(4) any other reports required under subsection (b) of this Section.

Each report shall contain, where pertinent, the elements described in Subsections (b)(1)-(5) of this Section;

(d) Submit to the Administrator, upon termination of the Permit:

(1) a report on and graphic representation of the Final Plan, as implemented, and

(2) a copy of the instructions to be given to the new owners of the improved property by the Permittee or his/her agent regarding the maintenance of the surface runoff, erosion and sediment control measures and devices implemented under the Final Plan,

or,

(3) for those areas where no Final Plan is required, a report and graphic representation of the Interim Plan, as implemented, and

(4) contracts for the maintenance and upkeep of the surface runoff, erosion and sediment control measures and devices implemented under the Interim Plan, for the period during which the site will remain unimproved;

(e) Have an authorized representative of each contractor or subcontractor actually performing the land-disturbing or filling activities or soil storage, or actually procuring the materials, machinery, services or manpower for the implementation of Interim or Final Plans, sign each report pertinent to him or her, and certify the contents thereof as true. The Permittee shall sign all reports submitted to the Administrator and shall attest that each is true and accurate to the best of his or her knowledge.

402.02 Implementation of Major Permits--Administrator's Duties.

(a) The Administrator shall review all reports submitted by Permittee. Where the Administrator finds:

(1) delays in implementing or departures from the approved Site Map and Grading Plan, Interim or Final Plans,

(2) problems with or breakdowns in any technique provided for by the Interim or Final Plan which are attributable to:

(i) the Plans themselves,

(ii) their maintenance methods or schedules,

(iii) any other causes,

which may have a deleterious effect on the quality of receiving waters, or increase surface runoff, erosion or off-site sedimentation, the Administrator shall require the Site Map and Grading Plan, Interim or Final Plans, and maintenance methods and schedules be modified so as to achieve the same level of water quality and surface runoff, erosion and sediment control as would have been achieved had these problems not arisen. The Administrator shall notify the Permittee in writing of the requirement. Permittee shall comply with the order to modify within [x] working days.

(b) The Administrator shall inspect the work site for compliance with conditions set forth in §401.03, for verification of reports submitted under §402.01, and for the quality of the work being performed under the Interim or Final Plan. Said inspections shall take place:

(1) [within five (5) working days of July 15],

(2) [within five (5) working days of September 1],

(3) [within five (5) working days of September 15],

(4) [weekly from October 1 through 15],

(5) [within three (3) working days of] or during, the first major rainfall of the wet season,

(6) under circumstances described in §402.01(c),

(i) at the onset of implementation of the Interim Plan, and

(ii) at the onset of land-disturbing or filling activities or soil storage,

(7) after notification to the Permittee of an order to modify under Subsection(a) of this Section,

(8) at any other time, at the Administrator's discretion.

(c) The inspector shall file a written memorandum on:

(1) the conditions of the work site,

(2) whether Permittee is in compliance with approved plans,

(3) whether Permittee is in conformity with filed reports,

(4) whether Permittee is in conformity with the Interim or Final Plan,

(5) whether Permittee is effectively controlling surface runoff, erosion and off-site sedimentation.

403.01 Suspension or Revocation of Permit. The Administrator shall first have resort to the procedures set forth in this Section before any other enforcement procedure set forth in this Article.

(a) The Administrator shall suspend the Permit and issue a stop work order, and Permittee shall cease all work on the work site, except work necessary to remedy the cause of the suspension, upon notification of such suspension when:

(1) Permittee fails to submit reports timely and in accordance with §402.01,

(2) inspection by the Administrator under §402.02(b)(1)-(8) reveals that the work or the work site:

(i) is not in compliance with the conditions set forth in §401.03, or

(ii) is not in conformity with the Site Map and Grading Plan, Interim or Final Plan as approved or as modified under §402.02(a), or

(iii) is at variance with reports submitted under §402.01(a)-(e), or

(iv) is not in compliance with an order to modify under §402.02(a),

(3) Permittee fails to comply with an order to modify within the time limits imposed by the Administrator (see §402.02(a)).

(b) The Administrator shall revoke the Permit and issue a stop work order, and Permittee shall cease work upon the occurrence of any of the following conditions:

(1) Permittee fails or refuses to cease work, as required under (a) above, after suspension of the Permit and receipt of a stop work order and notification thereof,

(2) any of the conditions set forth in Subsection (a) of this Section occurs in a §201.02(a)(7) area.

(c) The Administrator shall reinstate a suspended Permit upon Permittee's correction of the cause of the suspension.

(d) The Administrator shall not reinstate a revoked Permit.

403.02 Fines and Penalties. It shall be a misdemeanor for any person to perform work in violation of a stop work order issued pursuant to §403.01(a)-(b). The [City/County] may impose a fine of $500 and/or a prison term of thirty (30) days for each day that:

(a) Permittee continues working in violation of a stop work order;

(b) Permittee is not in compliance with the Interim Plan or Final Plan at the onset of the wet season.

403.03 Action against/Release of the Security. The Administrator may request the [City Attorney/District Attorney] to commence an action against the pertinent security if:

(a) The Permittee ceases land-disturbing activities and abandons the work site prior to completion of the Site Map and Grading Plan;

(b) The Permittee fails to conform to the Interim Plan as approved or as modified under §402.02(a);

(c) The Permittee fails to comply with the Final Plan or an Interim Plan as approved or modified under §402.02(a); or the techniques utilized under either Plan fail within one (1) year of installation, or a Final Plan is implemented for the site or portions of the site, whichever is later;

The monies obtained from a successful action against the Security shall be used to finance remedial work undertaken by the [City/County] or a private contractor under contract to the [City/County], and to reimburse the [City/County] for the cost of litigation;

(e) Securities held against the successful completion of the Site Map and Grading Plan and the Interim Plan, except for Interim Plans described in §301.07, shall be released to the Permittee at the termination of the Permit, provided no action against such security is filed prior to that date;

(f) Securities held against the successful completion of the Final Plan and an Interim Plan described in §301.07 shall be released to the Permittee either one (1) year after termination of the Permit or when a Final Plan is submitted for the unimproved site, whichever is later, provided no action against such security has been filed prior to that date.

403.04 Cumulative Enforcement Procedures. The procedures for enforcement of a Permit, as set forth in this Article, are cumulative and not exclusive.

APPENDIX D

INSTITUTIONAL CONSIDERATIONS BY THE CENTER FOR GOVERNMENTAL RESEARCH

INSTITUTIONAL CONSIDERATIONS - ADMINISTRATIVE ARRANGEMENTS FOR MANAGEMENT OF NON-POINT SOURCE POLLUTION (Preliminary Report)

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Prepared for
The Administrative Board of the
Irondequoit Bay Pure Waters District
Through the Nationwide Urban Runoff Program

by the
Center for Governmental Research Inc.
37 South Washington Street   Rochester, New York 14608

1.0 INTRODUCTION

This chapter presents a preliminary report suggesting various administrative arrangements for the management of non-point source pollution in Monroe County. As part of the NURP effort, it emphasizes organizational alternatives for dealing specifically with the effects of urban runoff on the water quality of Irondequoit Bay.

At the same time, the comments attempt as much as possible to anticipate the institutional arrangements which may be required to implement recommendations under the forthcoming companion studies, the Clean Lakes Program and the Agricultural Non-Point Source Study. As a result, the analysis assumes a two-tiered aspect:

- In the short-term, what organizational and financial arrangements are needed to implement IBNURP recommendations and;
- In the long run, how should Monroe County as a whole organize and provide financing for strategies to achieve water quality goals?

The most logical administrative responses to the NURP recommendations are therefore provided; however, officials involved in the three studies cautioned against recommending one long-range institutional arrangement for the county over another in the absence of the Water Quality Management Plan expected out in 1984.[1] Instead, the following objective methodology is provided to facilitate community discussion in the meantime on this complex issue:

- Goals or recommendations related to non-point source pollution are stated as derived from the NURP study and other sources—and organized into administrative goals.

- Functions to be performed by a water quality management entity are enumerated as derived from the goals or recommendations stated above.

- Administrative alternatives are suggested to perform these needed functions and, hopefully, in the process, to achieve water quality goals.

- Assessments of these alternatives based on their projected ability to meet certain objective criteria are then presented in both narrative and tabular form.

- Preliminary conclusions are drawn about the short and long run institutional requirements for urban runoff mangement, specifically, and non-point source management, generally, in Monroe County.

Note that this report is considered to be a preliminary draft and subject to major revision based on comments from local and state officials and other interested parties.

[1] Note: An expanded version of this paper will eventually be incorporated into the Water Quality Management Plan. For this reason, and for the sake of simplicity, the term water quality is sometimes referred to in this section. It should be interpreted to mean water quality as it is influenced by non-point source pollution only—unless otherwise stated.

2.0 ADMINISTRATIVE GOALS DERIVED FROM TECHNICAL RECOMMENDATIONS

2.1 Technical Recommendations

The following list of recommendations contains some of those which were made in the NURP Report as a result of an analysis of the urban runoff problem and the available control measures and best management practices (see Section 2, page 5). These recommendations form part of the basis for the administrative goals summarized in the next section (2.2):

- Monroe County should proceed with the construction of a flow regulating device at the "Narrows" within the wetlands immediately upstream of Irondequoit Bay. (page 5)
- Monroe County should formally establish definitive water quality objectives for phosphorus, chlorophyll, and water clarity for Irondequoit Bay. (page 5)
- An erosion/runoff control ordinance based on performance standards...should be developed and adopted by the local governments. (page 5)
- Monroe County should continue to support and fund in-bay monitoring programs as well as flow recording and sampling of Irondequoit, Allen and Thomas Creeks. (page 5)
- Monroe County should continue its public information program as an integral part of the recommended water quality management plan. (page 6)

2.2 Administrative Goals

In order to implement the recommendations listed above, attention must be given to short and long-term administrative arrangements. The concern for administrative arrangements (institutional considerations) is of a very practical nature. Who is going to implement technical recommendations? Are all necessary parties potentially controlling aspects of implementation (or implementation outcomes) accounted for and involved? Have adequate funding arrangements been made? Are they realistic? Has care been taken to assure that objective information about urban runoff control is developed, openly and publicly discussed, and acted upon?

These considerations are reflected in the following administrative goals--which are intended to guide the proper development of a practical set of administrative arrangements:

1. Administrative arrangements will include a means for coordinating, directing (where appropriate), and documenting the diverse efforts and forces affecting Irondequoit Bay's water quality, including local government, state and federal governments, and private interests. Specific accountability for overall direction and goal achievement will be assigned.
2. Administrative arrangements will be designed to efficiently utilize current personnel and other existing resources.
3. Administrative arrangements will be developed so that progress or failure toward urban runoff improvement is clearly evaluated on a periodic and objective basis (including review by third parties without direct administrative responsibilities or financial interest).
4. Administrative arrangements will include procedures/mechanisms needed to equitably and reliably fund capital projects and operating costs. Projects/operating costs should be analyzed to determine countywide benefits as opposed to only local benefits. Countywide and district funding sources should be developed accordingly.
5. Administrative arrangements will be compatible with arrangements needed to address water quality problems beyond Irondequoit Bay and the immediate NURP study. There is a need to provide flexibility to integrate the conclusions and recommendations of the Clean Lakes Program and the Agricultural Non-Point Source Study into an overall management strategy.
6. Administrative arrangements will be developed that can effectively perform short and long-term urban runoff management and programming functions (as set forth in Section 3.0 following).

7. Administrative arrangements will be developed for urban runoff control that particularly stress the following:

    a. the development and maintenance of water quality objectives for pollutant levels;

    b. the performance of in-Bay and stream pollutant monitoring programs;

    c. the continued research on the causes of Bay pollution and the effectiveness of corrective actions;

    d. the means to construct and operate any needed facilities;

    e. the development and promulgation of performance-oriented regulations to control erosion and runoff.

8. Administrative arrangements will include a means to maintain general public and governmental interest in Bay water quality through a public participation program, including dissemination of findings, training programs, and related activities.

9. Administrative arrangements will be developed that can be feasibly implemented in the short-range.

3.0 ADMINISTRATIVE FUNCTIONS

In the following sections, the necessary functions to be performed by a water quality management entity concerned with non-point source pollution are specified. The first to be stated are those suggested in the draft final report as being necessary to implement the recommended control technologies or to continue technical research in Irondequoit Bay.

Other functions of such an entity are then delineated in Section 3.2 which may not be necessary in the short-term to implement specific NURP recommendations but will certainly be required to develop a long-range strategy to achieve water quality goals throughout Monroe County.

3.1 Functions of a Water Quality Management Entity Needed to Implement NURP Report Recommendations (pp. 5 and 6)

- Policy-setting and overall direction for water quality programs in Irondequoit Bay.

  > "Monroe County should formally establish definitive water quality objectives...for Irondequoit Bay."

- Monitoring and researching water quality.

  > "Monroe County should continue to support and fund in-bay monitoring programs as well as flow recording and sampling programs..."

  > "Monroe County should proceed with construction of a flow regulating device at the 'Narrows'..."

- Public participation generation and public information dissemination.

  > "Monroe County should continue its public information program."

- Continuing development and implementation of Best Management Practices at the local level.

  > "Erosion/runoff control ordinances...should be developed and adopted by the local governments."

3.2 Additional Long Term Functions of a Water Quality Management Entity as Suggested by Goals

- Planning - including recognizing the need for and the coordination of all county water quality projects related to non-point source pollution to insure their compatibility; to identify potential sources of funding for future projects; to provide training and technical assistance to interested parties.

- Intergovernmental coordination - through providing a forum for the free exchange of ideas and concerns among participating agencies and governments; to encourage these participants to work toward the common goal of controlling non-point source pollution.

- Capital construction and contract administration for projects of a non-recurring nature; to alleviate major causes of non-point source pollution over the long-term.

- Maintenance and operation of facilities on an on-going basis.

4.0 ADMINISTRATIVE ALTERNATIVES

In the following sections, alternative administrative arrangements are grouped into three categories:

- status quo
- options involving only a single administrative entity (e.g., Water Quality Management Authority, Lake Protection and Rehabilitation Agency/Districts, Pure Waters Agency/Districts, Water Quality Management Agency)
- strategies involving multiple agencies/departments

The alternatives depicted are in turn described using four variables: legal feasibility, organizational structure, funding availability/stability and functional capabilities. These descriptive categories should be distinguished from the various objective criteria which will also be applied to the listed alternatives to produce "assessment of alternatives" tables in Section 5.

The alternatives delineated in this section were chosen for these various reasons:

- Successful implementation has been shown in other areas of the country (e.g., Water Quality Management Authority, Multiple Component Strategy)
- Option/agency was suggested by the NURP Draft Final Report to implement one or more of the plan's recommended control technologies (e.g., Pure Waters, Status Quo)
- Recent state authorizing legislation has stirred interest (e.g., Lake Protection and Rehabilitation Agency/Districts, Water Quality Management Agency)

4.1 Status Quo

1. Legal Authority to Operate

Retention of the current organizational structure for water quality management in Monroe County would of course require no new legal authorizations.

2. Structure

Involvement in non-point source pollution control in the county has traditionally been shared by a number of county departments such as Health, Planning, Engineering and Wastewater Management as well as numerous towns and villages, the city of Rochester, and other entities such as the Pure Waters Agency and related districts, the Water Quality Management Committee, Monroe County Soil Conservation District, New York State Department of Environmental Conservation (NYSDEC), and the Monroe County Water Authority. Each agency pursues its special concern, with a noticeable lack of horizontal coordination and integration. No entity has been able to assume an aggressive role in providing overall direction in non-point source pollution control or, more specifically, in the control of urban runoff.

3. Funding

In the last several years federal grants to NYSDEC have been used to fund various water quality and wastewater management studies in Monroe County. The status of funding to implement recommendations from these studies is uncertain. No clear sources of local revenue are evident at this time. County departments such as Health, Planning, and Wastewater Management are also likely to vary in their future willingness and capacity to sustain current levels of involvement in water quality projects.

It is worth noting that general purpose governments routinely finance many services on the local level that are related to urban runoff and are expected to continue to do so. Best Management Practices are prime examples of such locally financed services; some towns also handle financing and construction of capital projects such as retention basins. The capacity of local governments to finance non-point source pollution control measures has traditionally been severely constrained and maintenance of the status quo arrangement would not be expected to effect increases in such local funding levels.

4. Functions

The assignment of water quality functions among departments and agencies has usually been undertaken in an informal and uncoordinated way under short-term contract arrangements. As such, the same function may be performed by two—or in some cases more—agencies or departments for different projects. The following list of such current functional designations, to the extent that they are performed at all, is the first attempt to identify the major entities which perform each function as it relates to non-point source pollution control practices:

- Overall policy-setting/direction/planning -
  The County Legislature, legislative bodies of towns/villages/city.
- Administration of current grants -
  NYSDEC through the County Engineering Department for NURP; NYSDEC through the County Health Department for the Clean Lakes Study.
- Intergovernmental coordination -
  No coordinating entity could be identified.

- Research and monitoring of data -
  County Health Department, Irondequoit Bay Pure Waters District under contract to the U.S. Geological Survey and the University of Rochester.
- Public participation -
  WQMC, Planning Department.
- Capital projects/facility operation/Best Management Practices -
  Towns, villages and the City of Rochester, Rochester Pure Waters District.

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4.2 Single Administrative Unit Alternatives

A. Water Quality Management Authority

1. Legal Authority to Operate

No specific legal authorization currently exists in New York State for a Water Quality Management Authority; an analysis of the authorizing statute for the Monroe County Water Authority indicates that its responsibilities for water quality are limited to the potable water supply. Proposed legislation concerning development of a state water authority is being analyzed for its relevance.

2. Structure

A model for this type of organizational arrangement is Seattle METRO, a municipal corporation with a range of responsibilities including point and non-point pollution control in King County, Washington. It is assumed that such an Authority in Monroe County would assume responsibilities only for non-point source pollution control; point source control would remain a function of Pure Waters and related districts. METRO is governed by a federation of representatives of all the various communities in the county as well as representatives of the county itself. By state legislation, such a municipal corporation can cross county lines.

METRO's administrative staff implements the policies approved by the METRO council and handles the daily operation of the agency. The various divisions under the Water Pollution Control function include Water Quality as well as Administrative Services and Maintenance. (In 1974, METRO was officially designated as the areawide water quality agency to handle non-point source pollution.)

METRO's Citizens' Water Quality Advisory Committee (CWQAC) makes recommendations to the council on major policy and planning issues.

3. Funding

In the case of METRO a fixed monthly sewer rate per residential customer equivalent is billed to the local sewer districts, who then charge their local customers, to cover principal and interest on debt, all costs of operation and maintenance of the system, and the costs of renewal, replacement and extension of the system. Revenue bonds have also been used.

As previously stated, such an authority mechanism in Monroe County would not have responsibility for point source pollution control and would therefore not tap into the Pure Waters billing mechanism whereby delinquent charges are placed on the subsequent general purpose government tax bill. Such a fall-back billing procedure would need to be negotiated on an intra-county level or legislated by the state.

4. Functions

Such an independent, self-supporting organization could be designed to be capable of assuming most, if not all, the functions generally attributed to a single unit water quality management agency. Seattle METRO, for example, handles the following functions for both sewer and water quality purposes:

- Policy-setting and administrative direction
- Inter-governmental coordination (e.g., of Best Management Practices)
- Long-range planning
- Research and monitoring of data
- Public information and participation
- Capital projects financing and construction
- Facility operation and maintenance

Best Management Practices, such as street sweeping and storm sewer cleaning, would be provided either directly or on a contract basis by localities.

B. Lake Protection and Rehabilitation Agency and Districts

1. Legal Authority to Operate

The State Legislature in 1981 authorized counties to create a public inland Lake Protection and Rehabilitation Agency (County Law Article 5-A). References to districts with "the purpose of effecting lake protection and rehabilitation, and any activities necessarily related thereto" were also made; however, the law suggests that these organizations must be termed drainage districts. Due to the somewhat ambiguous language of the authorizing statute, interpretations of the structure and financing of such an arrangement are being requested of the County Attorney. The descriptions given in this paper are based on the interpretations of CGRI staff.

No such Lake Protection Agency or districts are currently in place in New York State; examples from Wisconsin and Maine, however, have been analyzed.

2. Structure

A Lake Protection and Rehabilitation Agency may be any new or existing county officer, board or body as designated by the County Legislature. Except in the case of an authority, the Agency may also be designated by the Legislature as the administrative head or body of any county district established under Article 5-A of the County Law (e.g., one or more Lake Protection and Rehabilitation Districts.) Such a district can be established through procedures specified in Sections 253 and 257 of County Law. Each district must be drawn by the Agency to include only the area which will be "benefitted" by district projects.

No mention is made in the law for the necessity of establishing citizens' advisory boards to assist in the lake protection function, although they are authorized in Section 235.

3. Funding

Each district could be financed through special assessments, bonding, user charges or ad valorem levies. (Young Men's Christian Association v. Rochester Pure Waters District, 1974, 44 A.D. 2d 219, 354 NYS 2d 201.) This method of organization thereby guarantees a stable funding source.

Some concern has been expressed by officials consulted on this section that the boundaries and funding base for a lake district would, by definition, be quite limited relative to a drainage district. Specifically, some officials warn that residents of upstream communities (e.g., those living far south of Irondequoit Bay) would less likely acknowledge benefits arising from a district emphazing "lake protection and rehabilitation" than from one with a watershed "drainage" function.

Admittedly, public perceptions of who benefits under a lake vs. drainage district may be quite important and the County Attorney will evaluate the legal issues involved in using one term or another. However, the statute authorizing districts with a lake protection function describes their area of responsibility as "the lake, related shorelands, and the drainage basin". Clearly, nothing in the law precludes establishment of a district--whether termed a lake or a drainage distrct--from covering a watershed as a whole (e.g., the entire Irondequoit Bay watershed).

4. Functions

The major power of a Lake Protection Agency as stated in Section 252 of County Law is to "assemble data...related to lake protection and rehabilitation, including sources of degradation, treatment of aquatic nuisances, and the elimination or alleviation of such problems..."

The functions of the administrative board of a Lake Protection District (could be the Agency if so designated) are stated in Section 263-a of County Law:

- Policy-setting and administrative direction
- Intergovernmental coordination (e.g., Best Management Practices)
- Long range planning
- Research and monitoring of data

Such functions as handling operations, maintenance and construction are not specifically assigned in the statute but may be inferred from the following broad grants of power:

- adopting by resolution rules for carrying out their duties and plans for lake rehabilitation projects and;

- carrying out lake protection and rehabilitation projects and obtaining any necessary permits thereof.

The district could seemingly undertake all of these tasks directly or contract them out. Best Management Practices (e.g., street sweeping) would presumably be the responsibility of the localities within the watershed.

C. Monroe County Pure Waters Agency and Districts

1. Legal Authority to Operate

The Pure Waters Agency and districts as presently constituted would not have legal authority to perform all non-point source pollution management functions, by itself, in the opinion of many persons consulted on this issue. Moreover, the use of Pure Waters district funds to support non-point source related watershed projects is subject to legal challenge based on the fact that boundaries are significantly different. Legal opinions from the county attorney are currently being sought to clarify these issues.

2. Structure

Under such a single-agency approach to water quality management, the Pure Waters Agency and its component districts would assume responsibility for all non-point source pollution control in addition to the point-source control already handled by them. It is probable that provisions would be made to increase citizen participation in its policy making process either through greater public representation on its board or through a citizens' advisory committee.

3. Funding

Without the express statutory authority to undertake non-point source pollution related projects, the Pure Waters Agency or districts would not initiate capital projects of that type. The resources of the Pure Waters district which most closely approximates the boundary of the watershed in question (e.g., the Irondequoit Bay Pure Waters District for the Irondequoit Bay watershed) at best would be applied to relatively low cost projects that have a legitimate link to point-source pollution control (e.g., the research undertakings in the wetlands.)

4. Functions

Given a restricted funding capacity and questionable statutory authority to assume non-point source pollution control responsibilities, Pure Waters/Wastewater Management/Engineering as they are presently constituted do not plan to increase their involvement in non-point source pollution projects beyond the scope of the three projects related to the Irondequoit Basin. Their potential to provide intergovernmental coordination, planning and overall administrative direction on an indefinite basis is unlikely.

The function of research/monitoring would still need to be contracted out to the Health Department, public information and participation to Planning. In the absence of Pure Waters receiving a specific designation to handle non-point source pollution, funding to contract for these services and for capital projects would need to come from grants—questionable in the long run—or district charges/bonding which could be used only for non-point source projects with a related point-source objective.

Under such a system whereby Pure Waters handled non-point pollution control, the towns/villages/city would likely retain responsibility for housekeeping practices and development policy.

D. Water Quality Management Agency(WQMA)

1. Legal Authority to Operate

The State Legislature in 1982 authorized counties to establish a water quality management agency "for the purpose of water quality management program oversight". (Section 220-A of County Law). No such entity as yet exists in New York State.

Unlike the flexible law creating lake protection districts or legislation that could be proposed to create a Water Quality Management Authority, this law requires the Agency to provide "oversight of all water quality programs and related activities in the county"...including assessments of point source pollution. As such, it would have an oversight role over Pure Waters.

2. Structure

As authorized, the WQMA can be any new or existing county agency, official or group of officials as designated by the County Legislature. As such, it could take any number of forms such as an existing county department with staff or a new committee with only an advisory role. A citizens' participation group could function in an advisory capacity to the WQMA.

3. Funding

The enabling legislation is sufficiently flexible to allow for a wide range of responsibilities for the WQMA; the structure of the designated agency (e.g., whether it had in-house staff) would influence the functions assumed by the agency and these in turn would determine the level of revenues need.

No mention is made in the statute, however, to funding sources for the WQMA; presumably it would need to rely on relatively constant county general revenues to sustain itself. No firm long-term commitment to non-point source management could as a result be assured.

4. Functions

The statute specifies that the WQMA "review and coordinate all activities of...entities of county government which have a substantial impact on or interest in water quality management". Under the most logical use of a WQMA (as discussed in Section 4.3), functional assignments to various departments would be made using a WQMA developed, Legislature approved plan, with the funded-limited WQMA having ultimate responsibility only for "providing oversight of all water quality programs and related activities in the county." In the analysis in Section 5.2, however, the possibility of using a WQMA alone to handle non-point source pollution will be examined.

As with the other options, development and Best Management Practices would continue to be the responsibilities of local general purpose units.

4.3 Multiple Component Strategies

A wide range of administrative arrangements are possible under the rubric of "multiple component strategies" (i.e., any configuration of existing or new entities which together provide non-point source pollution management services to the county or its watersheds). Many unresolved issues would need to be discussed within the community before

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one such strategy could be successfully shaped. In the meantime, some general issues regarding multiple agency arrangements are presented here for descriptive purposes:

Function

- Which governmental agencies with current responsibilities for water quality should be incorporated into the plan?
- Are any new entities needed to assume neglected functions? If so, should such an entity be a county staff agency, a committee, or a district in order most successfully to carry out these responsibilities?
- Should some rearrangement or formalization of functional assignments take place among these new and/or existing organizations so that every function is assigned to an accountable entity?

The resolution of these issues will enable issues of legal feasibility and structure to be clarified (e.g., if a new agency is to be created, is there legal authorization for it to perform anticipated functions and where will it be placed in the organizational hierarchy).

Financing

- Can a stable revenue source--or, most beneficially, a funding source dedicated specifically for non-point source pollution control--be obtained for the option through county general revenues or should an alternative (e.g., district) revenue raising mechanism be provided for?
- Is a multiple-source funding option more feasible than depending on a single source?

  Financing options for a multi-component strategy would of course depend on what new or existing entities are involved in the ultimate configuration. This paper analyzes most types of institutional arrangements which could conceivably be included in a long-run multi-component solution for Monroe County's non-point source pollution. The benefits and drawbacks of each type of entity as regards funding for non-point source pollution control are summarized below:

FUNDING OPTIONS

Entity	Available Revenue	Advantages	Drawbacks
Authority-not currently authorized in NYS	User charges, bonds and notes	Not dependent on county budget (independent source)	No way to collect delinquent charges (would need to negotiate a mechanism with the county as Pure Waters does to have charge included on tax bill.)
Pure Waters Districts	District charges, bonding	Not dependent on county budget (independent source)	Legally prohibited in absence of designation to handle non-point source and since boundaries of P. W. districts and watersheds are not identical
Lake Protection Districts	Special assessments, user charges, ad valorem levies	Not dependent on county budget (independent source)	No way to collect delinquent charges (would need to negotiate a strategy with towns/ villages, for example)
Water Quality Management Agency	County general revenues only		Not a long-term stably committed source

5.0 ASSESSMENT OF ALTERNATIVES

Each of the alternatives just described, with the exception of the "multiple component strategies," will now be assessed vis-a-vis a list of objective criteria as identified in Section 5.1. These criteria were derived from the literature on water quality management and through input from various interested officials. No opinion is offered as to the relative importance of these variables. Section 5.3 provides a summary table depicting the estimated ability of each alternative to meet these stated criteria. The ideal administrative entity/entities would satisfy all variables or, at the least, would come closest to meeting all the criteria. Inferences drawn from the matrix in Section 5.3 will suggest some preliminary conclusions to be presented in Section 6.

A strategy using various existing and new agencies was not subjected to the criteria test at this time due to the lack of consensus on the part of officials in the Departments of Planning, Health, Engineering, and Wastewater Management concerning the assignment of specific functions under such a proposed plan. This assignment of responsibilities will be influenced by the results of the two companion studies yet to be released. For further details on a multi-component strategy see Section 6.

5.1 Criteria to Assess Non-Point Source Pollution Control Administrative Options

A. Ability to perform all functions

B. Current legal feasibility

C. Functional streamlining; logic of assignments given current assignments

D. Financing availability and stability anticipated in the future

E. Acceptability to local jurisdictions and the general public

F. Accountability for conditions in the watershed

G. Functional flexibility in light of possible expansion to rural and out-of-county components of watershed

H. Ability to be transplanted to other watersheds

I. Avoidance of conflict of interest

J. Ability to implement short-term recommendations

5.2 Assessment of Specific Alternatives

See following pages.

Option 4.1 Status Quo in Monroe County

A. Ability to perform all functions - The current assignment of functions as described in Section 4.1 can be characterized as ad-hoc or pragmatic rather than comprehensive and rational. As a result, some functions are not performed at all such as intergovernmental coordination.

B. Legal feasibility - This method requires formation of no new organizational structures.

C. Functional streamlining - As a result of the situation described under "A" above, some non-point source functions are assumed in-house or contracted out by multiple entities with no clearly perceived division of duty (e.g., research and data collection). Moreover, to the extent that many local governments independently undertake the same types of water quality management projects (e.g., retention ponding), duplication of effort results at the expense of possible economies of scale.

D. Financing availability - To the extent that water quality related projects have been performed at the county level, they have been funded with federal money through NYSDEC. Funding for implementation of these studies' recommendations, as described under 4.1, is uncertain as to availability, source, or amount.

Local governments, meanwhile, are responsible for raising all necessary funds to support their localized efforts. It is likely that individual jurisdictions (or county departments) would face greater difficulty in raising funds than an entity with a guaranteed source of water quality related revenue.

E. Acceptability to local jurisdictions - Since this organizational method describes the status quo in Monroe County, to maintain it can raise no objections from local units on the grounds of county usurpation of local prerogatives. It would also be a relatively low-cost alternative. Criticism could come, however, from interest groups calling for aggressive and coordinated county leadership in the area of water quality if such action is not forthcoming in the near future.

F. Accountability for conditions in the watershed - No county agency or department has been designated as ultimately responsible for non-point source pollution control and therefore no accountability is present.

Since each locality, moreover, is concerned only with water quality within its borders, no watershed-wide perspective is possible. Thus, classic "externalities" issues arise under this scheme when upstream communities are unwilling to spend money on runoff problems that affect only downstream towns or villages.

G. Functional flexibility with the addition of rural and out-of-county components - Every community in the watershed under this plan is free to deal with water quality or not, as they see fit. However, jurisdictions vary in their ability to raise money or undertake treatment technologies. In short, the various agencies in the jurisdictions in the watershed will differ in their flexibility to deal with the issues.

H. Ability to be transplanted to other watersheds - This method of organization is the status quo in watersheds throughout the county.

I. Avoidance of conflict of interest - Since no formal assignment of functions has taken place under the status quo, instances could arise where an agency simply assumed a responsibility on its own which was in conflict with its existing functions, priorities, or operating practices.

J. Ability to implement short-term recommendations - Due to the immediate time and financial constraints, it will be necessary to rely on the status quo to implement the recommendations in the NURP report. This strategy is reasonable given that no major projects have been recommended for immediate initiation. See 6.0 of this chapter for further details.

Option 4.2A Water Quality Management Authority

A. Ability to perform all functions - This organizational set-up offers a comprehensive mechanism whereby the full range of non-point source pollution control management functions could be assumed by one agency.

B. Current legal feasibility - To institute such an organizational option would likely require state and county approval.

C. Functional streamlining - Centralization of all planning, monitoring, operational and construction phases of water quality projects in one organization would eliminate functional duplication, assuming that the current expertise in these functions that exists in various departments is tapped by the new authority.

D. Financing availability and stability - Such an organization would conceivably have authority to issue bonds and notes and charge user fees. As previously described, however, a method of insuring collection would need to be established that includes punitive action (e.g., contracting with the county as Pure Waters does.)

E. Acceptability to local jurisdictions - Formation of a new municipal corporation with its attendant taxing power would assuredly be viewed negatively by the public at large. Local officials may be suspicious that such an overlapping authority structure would impinge on prerogatives of local zoning and planning officials.

F. Accountability for conditions in the watershed - Such a centralized organization with a focused responsibility for non-point source pollution could be held truly accountable for the status of the watershed assuming that it had representation of a broad cross-section of affected groups on its board.

G. Functional flexibility with the addition of rural and out-of-county components - An independently financed authority would presumably be organized from its inception to handle urban and rural areas of one or more watersheds. Since the authority would likely not cross county lines, an inter-county agreement would need to be drawn up in order to encompass the entire watershed.

H. Ability to be transplanted to other watersheds - see "G."

I. Avoidance of conflict of interest - No conflict is anticipated.

J. Ability to implement short-term recommendations - Cannot be used in the short-term due to legal infeasibility.

Option 4.2B Lake Protection and Rehabilitation Agency and Districts

A. Ability to perform all functions - As with the previously described option, the use of a Lake Protection Agency and district system affords an excellent opportunity for one entity to assume all non-point source related functions for a particular area (e.g., one watershed).

B. Legal feasibility - Such a lake protection procedure has been authorized by the State Legislature. In Monroe County, would require a referendum on the establishment of districts and the Legislature's designation of an administrative board (e.g., a Lake Protection and Rehabilitation Agency.)

C. Functional streamlining - Centralization of all non-point related functions in such a district structure would inhibit functional duplication given the possibility of using expertise in departments or agencies which currently handle the function. Use of one administrative board for all districts in the county would also promote functional streamlining.

D. Financing availability - Many independent and stable financing sources are available under the District Law including ad valorem levies, special assessments and user charges. As with an Authority, a method of collecting delinquent charges would need to be utilized.

E. Acceptability to local jurisdictions - Any new taxing or fee generating organization with its "bureaucratic" district organization would likely meet with stiff opposition from residents of the district as well as officials of the component jurisdictions.

F. Accountability for conditions in the watershed - Each district board would be responsible for the activities and results within district boundaries.

G. Functional flexibility with the addition of rural and out-of-county components - A lake district to cover the Irondequoit Bay watershed would comprise urban and rural components. Coordination with the out-of-county area could be accomplished through informal cooperative agreements with Wayne and Ontario counties.

H. Ability to be transplanted to other watersheds - Each district could comprise one or more watersheds or sub-watersheds in the county. The district organization facilitates most effectively the coverage of additional watersheds.

I. Avoidance of conflict of interest - No conflict is anticipated

J. Ability to implement short-term recommendations - Given the timing requirements to implement such a system, it could not be used in the short-run.

Option 4.2C Pure Waters Agency and Districts

A. Ability to perform all functions - As described in Section 4.2C the Pure Waters Agency and districts could not perform all identified water quality related functions.

B. Legal feasibility - The statutory authority for the Pure Waters Agency and its operating components to undertake water quality--as opposed to sewer--related projects, especially of a capital nature, is questionable.

C. Functional streamlining - Under this option no overlap of functions would be expected; as stated above, some functions would need to be contracted out and would enable existing expertise in other departments to be used. (e.g., Health, Planning.)

D. Financing availability - Pure Waters district charges could not be tapped to provide non-point source pollution control in the future in the absence of specific legal authority to do so.

E. Acceptability to local jurisdictions - The public reaction to such a proposal cannot be surmised at this point. However, this option would be one incurring lower costs relative to an Authority or new district set-up.

F. Accountability for conditions in the watershed - As the single administrative unit, Pure Waters could not handle all of the functions of a water quality management entity. Through the necessity of contracting out services, this option would compromise accountability relative to some other administrative options.

G. Functional flexibility with the addition of rural and out-of-county components - The Pure Waters Agency through its districts could presumably undertake limited non-point source projects with a point source objective as well in those areas currently served by a Pure Waters district and could enter into contracts to provide services to adjacent ares.

H. Ability to be transplanted to other watersheds - See "G."

I. Avoidance of conflict of interest - A perceived conflict of interest exists under this option in the sense that Pure Waters would have sole responsibility for both wastewater disposal and maintenance of water quality standards. Of course, if Pure Waters were given responsibility for non-point source pollution its current structure could be reconfigured to deal with potential conflicts.

J. Ability to implement short-term recommendations - Pure Waters (and related departments/districts) would be incapable in the short-run of handling all non-point source related functions. It will, of course, play a vital role in implementing one or more of the short-term NURP recommendations.

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Option 4.2D Water Quality Management Agency

A. Ability to perform all functions - The authorizing statue for a WQMA grants it open-ended authority for coordinating all water quality activities in a county; however, since no funding mechanism was granted, it is inevitable that few functions could be directly handled by the WQMA (e.g., intergovernmental coordination, overall direction, long-range planning). Of course, if a county staff agency were so designated, more functions could conceivably be performed.

B. Legal feasibility - Pursuant to 1982 state authorizing legislation, the County Legislature simply needs to authorize the WQMA.

C. Functional streamlining - A drawback of this option lies in the fact that the WQMA is delegated responsibility for point source pollution control which has until now been competently handled by Pure Waters.

D. Financing availability - As stated in "A" above, no independent financing mechanisms are authorized for a WQMA; relatively uncertain county general funds would need to be relied on.

E. Acceptability to local jurisdictions - Acceptability of a WQMA would depend on the extent to which it assumes an aggressive role (e.g., as enforcer of local compliance with countywide regulations). Due to the limited financing potential under this arrangement, the WQMA would likely be restricted to providing the functions as stated under "A." Therefore, this low cost organizational arrangement would likely be quite acceptable to officials in localities and the general public.

F. Accountability for conditions in the watershed - Since the WQMA would not perform all water quality related functions, responsible agencies would include all those providing contract services. This dispersion of authority would restrict accountability relative to administrative options where all responsibilitites are vested in one entity.

G. Functional flexibility with the addition of rural and out-of-county components - The WQMA would have jurisdiction over the entire county; coordination with out-of-county areas would require an inter-county cooperative agreement.

H. Ability to be transplanted to other watersheds - See "G."

I. Avoidance of conflict of interest - The County Legislature should take this criterion into account when designating an agency or official as the WQMA.

J. Ability to implement short-term recommendations - It is unlikely that the County Legislature will designate a WQMA in the near future.

5.3 SUMMARY TABLE REFLECTING ASSESSMENT OF SPECIFIC ALTERNATIVES

		SINGLE UNIT ADMINISTRATIVE ALTERNATIVES			
ASSESSMENT CRITERIA	STATUS QUO	Water Quality Mgt. Authority[1]	Lake Prot. & Rehab. Agency with Districts[2]	Pure Waters Agency with Districts[3]	Water Quality Mgt. Agency[2]
Ability to perform all functions		x	x		
Current legal feasibility	x				x
Functional streamlining		x	x	x	
Financing availability/stability anticipated in the future		x	x		
Acceptability to local jurisdictions/ general public	x			x	x
Accountability for conditions in watershed		x	x		
Functional flexibility in light of expansion to rural, out-of-county		x	x	x	x
Ability to be transplanted to other watersheds	x	x	x	x	x
Avoidance of conflict of interest		x	x		x
Ability to implement short-term recommendations	x				

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[1] As currently practiced under the Seattle METRO plan.

[2] As envisioned, based on statutory descriptions.

[3] As currently constituted to handle non-point source pollution, projects that have a primary objective of point source control.

6.0 PRELIMINARY CONCLUSIONS

An analysis of the results of Section 5, as well as comments made by officials concerned with water quality in Monroe County, suggest several preliminary conclusions.

1. In the short run, certain immediate responses to the NURP report are necessary. In most cases, these responses involve simply an affirmation on the part of a department that its involvement in a given function will continue. In other cases, a department may be encouraged to assume a function which is a logical extension of its current functions--at least in the short term.

NURP Recommendation	Function	Department/Agency
#1, #3	Surveying, Research Project in Wetlands & Specific Urban Areas	Pure Waters Agency, IBPWD, Department of Engineering, USGS Health Dept.
#5, #8	Monitoring, Sampling	Health Department
#7	Public Participation/Information	Planning, WQMC
#4	Technical Assistance to Towns, Training in Erosion Control Ordinance Formation	Planning
#6	Storm water Infiltration Project	Engineering, USGS, Health Dept.

The County Legislature is encouraged to provide adequate funding to these departments, where applicable, to perform these tasks sufficiently as recommended by the O'Brien and Gere Report, on an interim basis.

NURP recommendation #2 calls for the establishment of water quality objectives regarding concentrations of certain pollutants for Irondequoit Bay. The function of overall policy development for water quality, (and particularly for non-point source pollution) and its approval has not to this point been assigned by the County Legislature. Unless and until the Legislature formally designates an official or agency to assume policy direction, it alone should establish such a policy. Recommendations for the development of policy and an approval process are under study by CGRI. The technical nature of water quality standards and management suggests that the policy direction function exclusive of final budget approval should be delegated by the Legislature.

In the short term, it is apparent that the decentralization of functions will continue. No single administrative unit met all the criteria in Section 5 (e.g., none could assume all necessary functions, be financially stable, publicly palatable, accountable, flexible, etc.) to an acceptable degree.

2. In the long run, and after considerable public discussion, it is assumed that a configuration of new and/or existing agencies could be identified to most closely meet the criteria. This multi-component strategy would presemably be a variation on the status quo arrangement to the extent that it would include departments, agencies and governmental levels currently involved in non-point source pollution. The questions provided in Section 4.3 could be used to formulate such a strategy.

The most important steps in such a process would be to achieve formal agreement as to what agency or department would handle each function, to see that all functions are assigned with principal accountability to one agency, and to ensure that stable funding mechanisms are provided. In Monroe County, specific examples of issues to be dealt with may include the specific assignment of functions which are currently unclearly designated, such as overall direction and intergovernmental coordination, to Water Quality Management Agency or the feasibility, perhaps simultaneously, of organizing a Lake Protection District for the Irondequoit Bay watershed.

3. It is apparent that no general agreement exists on the role of currently involved government entities in the county. In the interim, i.e., before the publication of the Water Quality Management Plan, therefore, representatives of all agencies actively involved with non-point source management in the county should develop a Unified Planning Work Program similar to that developed for transportation in the region by the Genesee Transportation Council (GTC).[1] The purpose of such a plan is to accurately represent the current distribution of water quality management functions. Building on the outline in Section 4.1 in this report, such an analysis should also provide specific definitions of each discrete function performed. This work plan could then be used to formulate long-run recommendations for the final report on water quality management.

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[1] The Unified Planning Work Program for GTC involves the annual comprehensive listing and description of all transportation related planning and technical studies by local governments and agencies as well as by the state. The UPWP is used as a coordinating device to avoid unnecessary duplication, to develop priorities for work and to facilitate inter-agency cooperation and joint development of projects. The UPWP process is also used to allocate supportive GTC planning funds among agencies and projects.

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APPENDIX E

PUBLIC PARTICIPATION PROGRAM EXHIBITS

PUBLIC PARTICIPATION WORKPLAN

PHASE	PUBLIC PARTICIPATION ACTIVITY	SCHEDULE	STAFF SUPPORT	TARGET AUDIENCE
I. Initiate Public Participation Program (March-Nov. 1980)	Establish Advisory Group	March - September	Grantee	General Public
	Designate Public Participation Coordinator (PPC)	March	Grantee	---
	Prepare study workplan and public participation workplan; advisory group review	July	Grantee, Consultant, PPC	Advisory group, Interested public
	Establish mailing list	August	Grantee, Consultant, PPC	Advisory group, Interested and affected persons
	Establish depository (information center)	August	Grantee, Consultant, PPC	Mailing list, general public
	Conduct training sessions on nature of study and related issues	June - October	Grantee, Consultant, PPC interested public	Advisory group,
	Prepare media and newsletter articles	March - August	PPC	General public
	Advisory group review of quarterly report	September	Grantee, Consultant, PPC	Advisory group, interested public
	Prepare and distribute project status report on background and need for study including identifying advisory group members, staff and consultant contacts	September	Consultant, PPC	Mailing list
	Publicize project and public meeting	September	Consultants, PPC	General public, mailing list
	Conduct public information meeting on putpose and overview of study	October	Consultant, PPC	General public, mailing list

PUBLIC PARTICIPATION WORKPLAN

PHASE	PUBLIC PARTICIPATION ACTIVITY	SCHEDULE	STAFF SUPPORT	TARGET AUDIENCE
I. Initiate Public Participation Program (Continued)	Prepare and distribute meeting minutes/ responsiveness summary	November	Grantee, Consultant, PPC	Mailing list, meeting attendees
	Expand mailing list based on public meeting	November	PPC	Interested and affected persons
II. Assess Current Conditions (Dec. 1980 - June 1981)	Advisory group review of quarterly reports	December - June	Grantee, Consultant, PPC	Advisory group, interested public
	Prepare and distribute quarterly project status summaries on Runoff Loadings (Task #2) and Water Quality Impacts (Task #4)	December - June	Grantee, Consultant, PPC	Mailing list
	Convene monthly meetings of advisory group to review progress of study	December - June	Grantee, Consultant	Advisory group, interested public
	Prepare media and newsletter articles	December - June	PPC	General public
	Publicize project and public meeting	May	Consultants, PPC	General public, mailing list
	Conduct public information meeting on status and implications of Tasks #2 and #4	June	Grantee, Consultant, PPC	General public
	Prepare and distribute responsiveness summary	June	Grantee, Consultant, PPC	Mailing list, meeting attendees
	Expand mailing list based on public meeting	June	PPC	Interested and affected persons

PUBLIC PARTICIPATION WORKPLAN

PHASE	PUBLIC PARTICIPATION ACTIVITY	SCHEDULE	STAFF SUPPORT	TARGET AUDIENCE
III. Evaluate Alternate Controls				
	Advisory group review of quarterly reports	Jan-June 1982	Grantee, Consultant, PPC	Advisory group, interested public
	Conduct monthly advisory group meeting to review possible alternate controls and management practices	Jan-June 1982	Grantee, Consultant, PPC	Advisory group. interested public
	Prepare notice of availability of Slide Show* to WQM member org., media other organizations on mailing list and send	Feb-March 1982	PPC	Advisory group org other organizations, media, general public
	Make presentation of Slide Show to groups as requested	Feb.1982-End of	PPC, Grantee	Advisory group org other organizations. general public
	Meet with Town Conservation Boards to verify current control practices in Towns and provide update on project	March-April, 1982	Grantee, Consultant, PPC	Town officials
	Update Information Center Notebooks** with IBS minutes and other new documents	March-April, 1982	PPC	Town officials, general public

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*This slide show was prepared in 1981 and originally used to inform all municipal governments in the basin of the studies. It explains the water quality history of Irondequoit Bay including improvements accomplished, problems remaining, and what is being done. The purpose and methods of NURP are explained as well as information on the Clean Lakes Program and the Basinwide Water Quality Management Plan that will be done. Control measures are outlined for urban runoss as well as the way in which they will be chosen and how the public can get involved.

**Information Center Notebooks are looseleaf binders which contain information on the Irondequoit Basin Studies, including subcommittee minutes, fact sheets on the Irondequoit Basin Water Quality Studies, and further background. The notebooks are located at the primary information center in the County Planning Department, and at all Town and Village Clerk's offices in the watershed. They are located in the Town/Village Clerk's Offices for reference by the general public.

PUBLIC PARTICIPATION WORKPLAN

	PHASE	PUBLIC PARTICIPATION ACTIVITY	SCHEDULE	STAFF SUPPORT	TARGET AUDIENC
III.	Evaluate Alternate Controls (Continued)	Prepare newsletter on progress of study	May 1982	Grantee, Consultant, PPC	Mailing list
		Distribute newsletter	June 1982	PPC	Mailing list
IV.	Develop Management Plan	Prepare newsletter summarizing draft final report and announcing public hearing	Nov-Dec. 1982	PPC, Grantee, Consultant	Mailing list, general public
		Distribute Newsletter to mailing list and Town/Village Halls and libraries	December 1982	PPC	Mailing list, general public
		Meet with Town/Village Officials upon request and receive comments, questions, and suggestions	November, 1982	PPC, Grantee	Municipal officials
		Advisory group review of Draft Report	November 1982 January 1983	PPC, Grantee	Advisory group, interested citizens
		Redistribute pamphlets to public places	November 1982	PPC	General public
		Prepare and carry out publicity for Public Hearing*	November 1982 January 1983	PPC	Geneal public
		Place NURP Draft Final Report in Depositories and libraries	30 days prior to hearing	PPC	General public
		Conduct Public Hearing on Draft Plan	January 1983	PPC, Grantee, Consultant	General public
		Expand Mailing List based on public hearing	January 1983	PPC	Mailing list

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*Public hearing publicity will consist of legal notice, news release, public service announcements, newspaper advertisements, posters, pamphlet distribution, post card reminder, newsletter, mailing of notice.

PUBLIC PARTICIPATION WORK PLAN

	PHASE	PUBLIC PARTICIPATION ACTIVITY	SCHEDULE	STAFF SUPPORT	TARGET AUDIENCE
IV.	Develop Management Plan (Continued)	Advisory group review of comments made at public hearing and suggest changes to be made in Final Plan.	January-Feb. 1983	PPC, Grantee, Consultant	Advisory group, interested public
		Prepare and distribute responsiveness summary and public participation program evaluation. Undertake media follow-up as necessary	January-Feb. 1983	PPC	Mailing list

IRONDEQUOIT BASIN SUBCOMMITTEE MEMBERS

March 1983

Citizens

Robert Antell
Anna Bundschuh
John Hopkins
Robert Jonas, Chairman
Betty VanHuysen

Private Interest Groups

Charles Costich	Rochester Homebuilders Association
Sarah Fogler	Sierra Club
Grant Pike	Rochester Committee for Scientific Information

Public Officials

Roberta Barnes	Mendon Town Supervisor
Richard Cortina	Representing Town of Brighton Supervisor
John Earls	Representing Town of Pittsford Supervisor
Lake Edwards	Town of Perinton Supervisor
Dennis Essom	Representing Village of East Roch. Mayor
Michael Flanigan	Monroe County Environmental Mgmt. Council
Irene Gossin	Town of Penfield Supervisor, Town Supervisors Assn
David N. Hawkins	Village of Victor Mayor
Jack Holzwarth	Village of Pittsford Mayor
Stephen Johnson	Irondequoit Town Supervisor
Irving Kent	Town of Webster Supervisor
Phillip Litteer	Town of Henrietta Supervisor
Gerald McDonald	County Director of Engineering
Tom Nally	Monroe County Cooperative Extension
Joel Nitzkin	County Director of Health
Raymond Parrish	Town of West Bloomfield Supervisor
Wayne Scheik	Town of Macedon Supervisor
Joan Snyder	Representing Town of Victor Supervisor
Robert Vaisey	Representing Village of Fairport Mayor
Ed Watson	Representing City of Rochester Mayor

MONROE COUNTY WATER QUALITY MANAGEMENT COMMITTEE MEMBERS

December, 1982

Citizens

Robert Antell
Anna Bundschuh
John Ferraro
John Hopkins
Robert Jonas
Sharon Rivaldo

Private and Public Interest Group Representatives

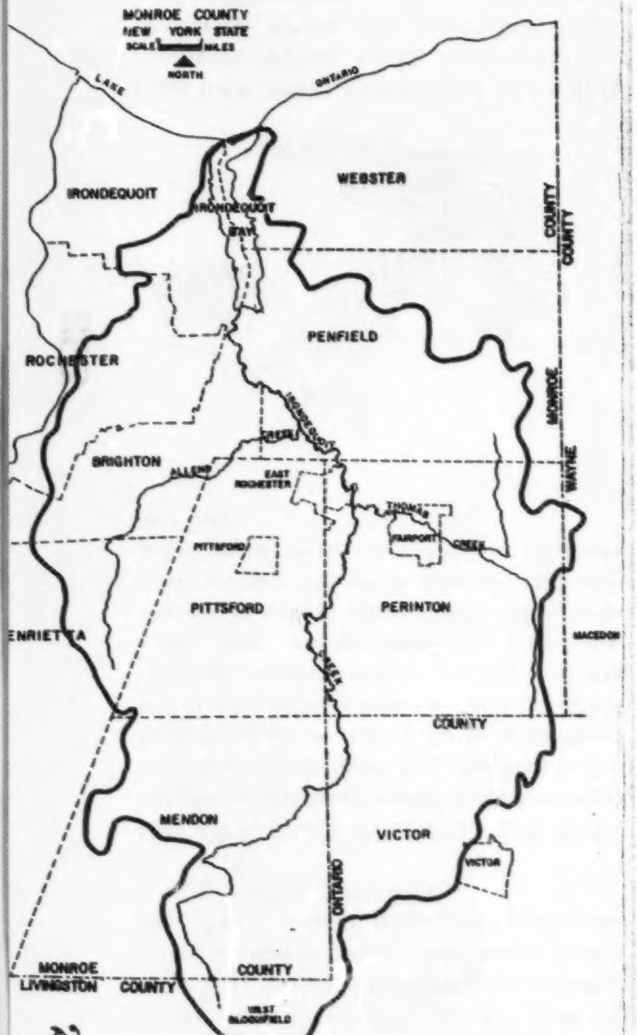
Olga Berg	League of Women Voters
Charles Costich	Rochester Homebuilders Association
Archie Curry	Urban League of Rochester
Michael Flanigan	Monroe County Environmental Management Council
Sarah Fogler	Sierra Club
John Hoff	Industrial Management Council
Clarence Ingram	Rochester Business Opportunities Center
Tony Palermo	Rochester Engineering Society
Dennis Sugumele	Rochester Gas & Electric

Public Officials

Irene Gossin	Town Supervisors Association
Michael Hanna	Monroe County Legislature
Don Martin	County Director of Planning
Gerald McDonald	County Director of Engineering
Joel Nitzkin	County Director of Health
Thomas Ryan	Mayor, City of Rochester

THE IRONDEQUOIT BASIN AREA

Areas that drain into Irondequoit Bay include East Rochester, Fairport, Pittsford, and parts of Brighton, Henrietta, Irondequoit, Macedon, Mendon, Penfield, Perinton, Rochester, Victor, Webster, and West Bloomfield.


MONROE COUNTY
NEW YORK STATE
SCALE MILES
NORTH
LAKE
ONTARIO
IRONDEQUOIT
IRONDEQUOIT BAY
WEBSTER
COUNTY
COUNTY
ROCHESTER
PENFIELD
MONROE
WAYNE
IRONDEQUOIT CREEK
BRIGHTON
ALLENS CREEK
EAST ROCHESTER
THOMAS CREEK
FAIRPORT
PITTSFORD
PITTSFORD
PERINTON
MACEDON
HENRIETTA
COUNTY
MENDON
VICTOR
VICTOR
ONTARIO
MONROE
LIVINGSTON COUNTY
COUNTY
WEST BLOOMFIELD

The following organizations are participating in the NURP study:

Irondequoit Bay Pure Waters District
Monroe County Department of Engineering

Monroe County Water
Quality Management Committee

O'Brien & Gere Engineers, Inc.

Monroe County Department of Health

Monroe County Department of Planning

New York State Department
of Environmental Conservation

United States Geological Survey

United States
Environmental Protection Agency

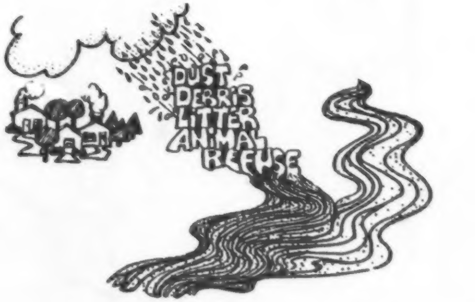
URBAN RUNOFF and
IRONDEQUOIT BAY

WHAT IS URBAN RUNOFF?

Urban runoff is dirty water -- rain or snow that washes off buildings, pavements, and commercial areas. This water carries dust, litter, animal refuse, and toxic substances into our waterways.

URBAN RUNOFF POLLUTES THE BAY

Streams in the Irondequoit Basin (see map) flow into Irondequoit Bay, carrying pollutants from urban runoff. Large amounts of pollutants, such as nitrogen and phosphorus, have accumulated in the bay over the years from sewage treatment plant discharges as well as urban runoff. These substances cause too much algae growth, contributing to changes in the variety of plants and fish.

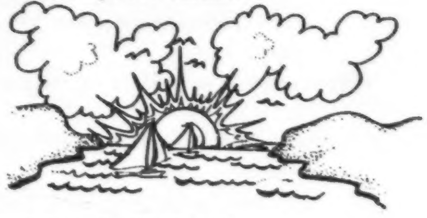


OUR BAY AND CREEKS ARE CLEANER

Previously, sixteen sewage treatment plants discharged wastes into Irondequoit Basin creeks. Now these wastes are transported to a single central treatment plant and discharged into Lake Ontario. These changes happened because Monroe County, the state of New York, and the U.S. Environmental Protection Agency (EPA) joined efforts to construct the pure waters sewer system. These groups are working together to achieve even better water quality.

MORE HELP IS NEEDED

A lot of money and work has gone into reducing sewage discharges to the creeks and bay. Still, the effects of urban runoff may continue to pollute. We must reduce urban runoff pollution or the water of the bay will not improve further.



NATIONWIDE URBAN RUNOFF PROGRAM (NURP)

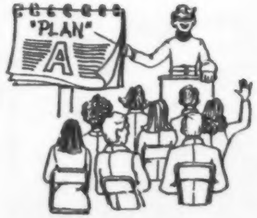
Monroe County and the New York State Department of Environmental Conservation are studying the problem of urban runoff pollution, ways to control this pollution, and the costs for these control measures. This three-year program, begun in 1980, is studying the urban and suburban portions of the Irondequoit Basin. It is funded by the EPA's Nationwide Urban Runoff Program (NURP).

HOW THE NURP STUDY WORKS

Five water testing stations have been set up in Irondequoit Basin creeks by the U.S. Geological Survey (USGS) and the Monroe County Department of Health. Water samples taken at these stations are analyzed to find out how much and what kinds of pollution are coming from urban runoff. When this is known, control measures for reducing urban runoff pollution will be evaluated. Recommendations for the best control methods will be made in a water quality management plan for the basin. Finally, local governments and individuals living in the basin must help put these controls into practice.

WHY SHOULD I CARE ABOUT IRONDEQUOIT BAY?

Irondequoit Bay has steep wooded lots, hidden coves, and peaceful wetlands. It is close to where you live. If the bay water is cleaned up, the bay will become more attractive for recreation. Water areas that remain wild and natural would be cleaner for the birds and animals living there. The habitats for some fish would improve. More people could enjoy fishing, swimming, boating, and hiking. A clean bay would enhance nature trails and picnic areas that could be developed in parkland along its shores. Picturesque shops and restaurants could locate in the area, providing needed services and giving a small boost to the local economy.



HOW CAN I GET INVOLVED?

You can learn more about the NURP study at public information centers located in town and village halls in the basin and at the Monroe County Department of Planning, 39 West Main Street, Rochester, New York 14614. You can join the NURP mailing list by calling Richard Rising, public participation coordinator, at 428-5469. Mailings will let you know about several upcoming information meetings to be held at different locations in the Irondequoit Basin. These meetings are sponsored by the Irondequoit Basin Subcommittee, the public advisory group that is monitoring the progress of the study.

APPENDIX F

RESPONSIVENESS SUMMARY

County of Monroe
NEW YORK

DEPARTMENT OF PLANNING
301 COUNTY OFFICE BUILDING
ROCHESTER, NEW YORK 14614

DON B. MARTIN, DIRECTOR

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April 15, 1983

SUMMARY OF INFORMATION PRESENTED AND RESPONSE TO PUBLIC COMMENTS IRONDEQUOIT BASIN NATIONWIDE URBAN RUNOFF PROGRAM PUBLIC HEARING, JANUARY 25, 1983

A hearing presenting information contained in the draft of the Final Report from the Irondequoit Basin Nationwide Urban Runoff Program (NURP) took place January 25, 1983 at 7:30 p.m. at the Monroe County Cooperative Extension Building Auditorium, 249 Highland Avenue, Rochester, New York. The hearing was held to explain the report findings and to accept comments and questions from the public to be considered and included in the final report for the project. One hundred and twenty six people attended the hearing. Mr. George Landgren, Principal Engineer at the Monroe County Department of Engineering, opened the meeting by reading the public notice of the hearing.

SUMMARY OF INFORMATION PRESENTED

The following information regarding the Irondequoit Basin Nationwide Urban Runoff Program (NURP) was presented at the meeting:

I. Role of the Advisory Group; Other Water Quality Studies In the Irondequoit Basin:

Mr. Robert Jonas, Chairman of the Irondequoit Basin Subcommittee of the Monroe County Water Quality Management Committee, outlined the role of the subcommittee in this project and outlined the scope of three other water quality projects in the basin that they are advising on.

The subcommittee is comprised of citizens, representatives of public and private interest groups and public officials. Throughout this project they have followed project progress and guided plans to inform the public of the project progress. This subcommittee will be advising the project staff of changes that should be made in the final NURP report and will then make a recommendation to the County Water Quality Management Committee regarding acceptance of the report.

Three other studies are related to the NURP Project. The Clean Lakes Study is looking at pollutants contained in the bottom muds of Irondequoit Bay. The Agricultural Runoff Study is assessing the problem of stormwater runoff pollution from rural areas of the watershed. These two studies will be complete in June, 1983. The third study is the preparation of a County Water Quality Management Plan for the watershed. This will begin when all the technical studies are complete in June. The purpose is to use information learned from the NURP, Clean Lakes, and Agricultural Runoff Studies to formulate a water quality management plan for the entire watershed which will identify specific steps to be taken to most efficiently improve and maintain the water quality of the streams and bay.

II. Project Background - Robert Gallucci:

Precipitation falling on an undeveloped area moves into the soil, nourishing plants, infiltrating into the soil and moving through the ground water into the streams and lakes. The action of the water moving through the soil removes phosphorus and other particles in the water. In an urbanized area, large areas of pavement, roofs and other hard surfaces prevent the precipitation from moving into the soil which causes a very large amount of surface runoff. Much of this stormwater is consequently piped or channeled directly to lakes and streams with little infiltration along the way.

Phosphorus has been identified as a major pollutant present in stormwater runoff. In the summer, Irondequoit Bay is choked with algae because there is an overabundance of phosphorus in the water. That phosphorus acts as a stimulant for growth of algae. When the algae die and settle to the bottom, they are decomposed by bacteria which consume all the oxygen in the deep water. Without oxygen, many types of fish cannot live in the bay.

The NURP project has two sets of goals. The national goals are to establish a data base of pollutant concentrations that are found in urban runoff. This is being done at 28 sites across the country, each very different from the other in climate, city size and other characteristics. By reviewing the data from all 28 sites, the EPA can evaluate the types of problems occurring in urban runoff. At a national level the kinds of control methods appropriate for cleaning up urban runoff and the cost to our nation as a whole are also being studied. The Environmental Protection Agency has to report to Congress in March of 1983 on whether or not the urban runoff problem is a severe problem that requires action similar to what EPA has taken with wastewater treatment.

Locally our goals are very specific. We need to determine how much phosphorus enters the bay, where the phosphorus is coming from, and what technical control methods will best reduce the amount of phosphorus that goes into the bay. To reach a fishable and swimmable bay, the amount of phosphorus in the upper waters of the bay must be reduced. In 1972, the average summertime level of phosphorus in the bay was about 500 micrograms per liter or parts per billion (ppb). Through a number of programs dealing primarily with sewage abatement the phosphorus has been reduced to the current level of 100 micrograms per liter. A level of 20 to 30 micrograms per liter is required for the bay waters to be usable for fishing and swimming.

III. Control Measure Evaluation:

Phosphorus is not the only nutrient necessary for abundant plant growth, but it is the most easily controlled nutrient. By reducing phosphorus, the level of plant and algae growth in water can be reduced. Phosphorus can come from industrial sources, fertilizers, decaying vegetation, and septic tanks. Considerable phosphorus has also been found to fall with rain or snow.

During the first two years of the NURP Program, an extensive program of sampling and analysis was done to locate the sources of phosphorus to enable focusing on control measures specific to such sources. Water samples were collected in 1980 and 1981 at several locations, primarily in times of runoff. The samples were analyzed for phosphorus, other nutrients, suspended solids, heavy metals, and organic substances. The levels of phosphorus were high enough to merit concern. Sediment was found to carry a large portion of the phosphorus. Measurable levels of several other contaminants were found, but not in significant amounts.

The results from the sampling and analysis were used to develop a mathematical model which led us to the conclusion that in order to achieve a water quality goal of 20 parts per billion (ppb) in Irondequoit Bay, it would be necessary to reduce the quantity of phosphorus that reaches the bay from its current level of 40 kilograms per day on an average annual basis, to a level of 14 kilograms per day.

The first step in the control measure analysis was to identify all possible control measures, and evaluate the control measures. A set of criteria was applied to each possible control measure resulting in a shorter list of alternatives with the greatest chance of being effective. The alternatives were then further evaluated for cost effectiveness, performance, proven track record, regulatory acceptance and public acceptance. As a result of the initial analysis, five control measures were identified as most feasible:

1. The wetlands at the south of Irondequoit Bay could be used to filter sediment through the construction of a flow control structure in one or two locations. One location is known as the narrows, which is a point about midway between Browncroft and Empire Boulevards. The other location is at the head of the bay at Empire Boulevard. These structures would be used in times of runoff, when the flow in the creek is carrying a lot of sediment and phosphorus. At the present time, the main channel of Irondequoit Creek carries storm water through the wetlands quickly. During times of runoff, a control structure(s) would be activated which would increase the time that the water would stay in the wetlands by 2 or 3 days during which time the water would be let out slowly. During the extra 2 to 3 days a lot of sediment that is carried in times of high flow would settle to the bottom of the wetlands. There would also be a direct uptake of phosphorus by the cattails and other plant species in the wetlands. As a result, the amount of phosphorus reaching Irondequoit Bay would be considerably reduced.

2. A second control measure identified is the use of in-stream impoundments. These would cause the velocity of the creek water to be reduced, allowing the sediment and any attached phosphorus to settle out. An earlier study done several years ago by the Buffalo District of the Corps of Engineers identified six locations in the watershed where in-stream impoundments would be possible. A more detailed analysis of those six locations showed three most feasible. One is near the point where Allens Creek joins Irondequoit Creek, another at Spring Lake Park near Linden Avenue, and the third is in Bushnells Basin south of the Barge Canal. In-stream impoundments hold storm water back, with a small dam and a restricted outlet. This allows a constant quantity of water to pass through so that when more water from a storm event comes down the creek it is held behind the structure allowing sediment and phosphorus to settle out.

3. A third technology is stormwater infiltration. This technology is an enhancement of the naturally occurring processes where stormwater runoff is allowed to percolate into the upper soil layers where the soil removes particulates and dissolved pollutants. Surface soils must be conducive to this technique. Before this technology could be implemented, a more detailed analysis of the upper soil layers and the ultimate fate of any water discharged into those soil layers is recommended.

4. Another technique is the adoption of some type of erosion control ordinance throughout the watershed. An erosion control ordinance would be particularly effective in developing areas to prevent soil loss. This would reduce the phosphorus loading by keeping the particulate phosphorus out of the waterways. At the present time many of the towns and villages within the watershed have some type of drainage or erosion control ordinance. We would suggest that an ordinance be established that contains updated erosion control standards.

5. The last technology identified is the use of mechanisms known as swirl concentrators. These mechanisms allow the separation of sediments from the remainder of the water and works on the principle of centrifugal force. The dirty portion of the water is captured and diverted into an interceptor sewer or other appropriate place while the clean water flows back into the stream.

Through the use of computer modeling and other analysis, it was determined that one way to reduce the phosphorus entering Irondequoit Bay to the target of 14 kilograms per day is by using the upper wetlands in combination with three instream impoundments. To achieve this goal it would also be essential that no increase in quantities of phosphorus reach the bay from areas of new or future development. This could be done through a combination of stormwater infiltration and erosion control.

IV. Project Recommendations:

Although it would take the above noted combination to achieve the water quality goal of 14 kilograms per day, actual recommendations made in the NURP report will only partially attain that goal. Results from the Clean Lakes Study and the Agricultural Runoff Study must be considered before determining the most efficient combination of control measures to meet the 14 kilogram per day goal. When the Clean Lakes and Agricultural Runoff studies are complete, the final control technology plan will be prepared. The following recommendations are made in the draft NURP report and could be carried out in the near future as the first steps towards reaching our water quality goal.

1. Build one control structure at the narrows in the wetlands to stabilize water flow through the wetland.

2. Formalize the actual water quality goals for phosphorus and water clarity.

3. Evaluate site specific controls such as swirl concentrators for the dense urban or commercial areas.

4. Adopt an erosion control ordinance to limit the loss of soil, and to minimize the amount of stormwater that runs off into basin streams and the bay.

5. Continue monitoring and research to show progress towards our water quality goals.

6. Continue a public information program, to include the opportunity for public input during development and implementation of the water quality management program.

7. Formalize the roles of County and municipal governements to achieve an integrated water quality improvement management structure.

SUMMARY OF MAJOR COMMENTS OF THE IRONDEQUOIT BASIN SUBCOMMITTEE

Mr. Robert Jonas, Chairman of the Irondequoit Basin Subcommitee outlined the major comments that subcommittee members have raised to date:

1. On the issue of erosion control ordinances, many concerns have arisen. The subcommittee feels that recommendation number four of the report that currently reads, "Erosion/runoff control ordinances based on minimum standards and structured to meet local needs should be adopted by the governing municipal entities within the watershed" should be amended to say that any choice of a model ordinance must be considered further to fit local conditions. The subcommittee thinks that as a part of the overall water quality management plan that is to be done after the NURP, Clean Lakes and Agricultural Runoff Studies are complete, a model erosion control ordinance should be developed and an appropriate way of implementing such an ordinance should be specifically developed. There is support by many subcommittee members that an erosion control ordinance should be implemented on the county level to insure uniform controls throughout the basin. Such an ordinance would also need to cover portions of the watershed that lie outside of Monroe County. This could be done through the use of inter-county agreements.

2. In Appendix D, which is the Institutional Considerations and Administrative Arrangements, users fees are discussed as a possibility for raising money to carry out non-point source water quality improvements. More research must be done regarding users fees because there is not a commodity that is being used or disposed of such as in the case of water or sewer user charges.

3. The current draft of the report notes that control measures were evaluated to restore the bay to swimmable waters. A goal of swimmable waters is not necessarily desirable or practical in the case of Irondequoit Bay, and such reference should be qualified.

4. A recommendation should be included in this report that detention ponds be used to control urban runoff pollution on small areas.

5. The proposed control structure project in the Irondequoit Creek wetlands should be evaluated very carefully to consider all environmental impacts.

RESPONSE TO PUBLIC COMMENT AND QUESTIONS

Q1. I am very much in support of a program to clean up Irondequoit Bay. I am very concerned about the use of the marshland to facilitate sediment and phosphorus removal. This can cause several problems upstream such as flooding and the possible destruction of the marshland. I would recommend that a great deal of investigation be done on the repercussions of such a facility. -- Richard Van Gemert

A1. Issues relating to flooding and flood damage resulting from any back water controls have been evaluated from the inception of this project and there have been meetings with the Buffalo District Corps of Engineers to make sure that any consideration of flow stabilization in the wetlands would not aggravate flooding problems in the area of Panorama Plaza. Water levels in the bay and wetlands are affected by the water level of Lake Ontario which have been higher in recent years because of manmade controls of the Great Lakes. The wetlands currently become dried out as Lake Ontario water levels drop, and wet when the Lake level rises. By installing a water level control in the wetlands, storm water from small and moderate storms will back up into the wetlands, spread out, and allow the water to spread across the wetland. Large stormflows will rise above the structure. Any water flow regulating device would retain wetland water depth to a maximum of 1½ meters (5 feet) which is similar to current conditions in part of the wetland during storms. The high water level caused by the structure will be no higher than present, but will be at a constant depth for a longer period of time. The proposed control structure will allow passage of fish and canoes.

It is intended that any activity in the wetland area be conducted in such a way as to enhance the marshland by providing a greater diversity of plant and animal habitats. With the assistance of the New York State Department of Environmental Conservation wildlife personnel, we hope to increase wildlife habitat by creating more open water and dry land areas. By creating conditions where a greater variety of plants can live, habitat for a greater variety of animals will also be created.

Phosphorus that will end up in the wetland will be used by wetland vegetation for growth. Sediment will accumulate in the wetlands and is expected to be at a higher rate than present. This will be closely monitored and possibly removed by dredging.

A great deal of effort will be put into investigating the impacts of construction of any flow stabilizing facility at the narrows. Recommendation #1 of the Final Report has been rewritten as follows: "Monroe County should prepare a comprehensive workplan for using the wetlands immediately upstream of Irondequoit Bay for stormwater runoff control. Such a plan should include an environmental assessment leading to the design and construction of a flow regulating structure at the narrows." A research program will be designed to study the plants, animals, water quality, and sediment in the wetland before and after installation of a control structure. Also to be studied are changes in the watershed from other reductions of sediment from controls put in place in the agricultural areas and developing areas.

Q2. What will be the effect of the Army Corps of Engineers' project in the bay as far as the bay opening? It's my understanding from reading their documents that there is going to be approximately 45,000 cubic yards of bay bottom that is going to be disturbed and pumped to other bay locations. What will be the effect of that on your overall efforts to clean up the bay? -- Richard Van Gemert

A2. The Army Corps of Engineers will be excavating sediments within Irondequoit Bay to create boating channels as part of the opening of the Bay to Lake

Ontario. Approximately 35,000 cubic yards of the sandy sediments classified by the U.S. Environmental Protection Agency (USEPA) as unpolluted will be used to construct a dike for a proposed wetland establishment in the northern portion of Irondequoit Bay. Approximately 89,000 cubic yards of dredged silty sediments classified as moderately polluted will be placed within the diked area. If this moderately polluted sediment is contained within the diked area it should present only a small and temporary disruption to Monroe County's efforts to reduce the phosphorus concentration in the bay. The actual dredging process has the potential for negative effects on water quality. Disturbance of bottom muds from dredging can be minimized by appropriate procedures.

Q3. Has anybody investigated or explored the possibility of using saturated aeration of the bay itself to facilitate natural destruction of the phosphorus that enters the bay? According to documents that I have read that have been put out by Ingersoll-Rand Company, this method has been used at several locations around the country with very satisfactory results. I think it is something that should be explored in an effort to work along with your program. -- Richard Van Gemert

A3. A major problem in Irondequoit Bay is the lack of oxygen in deep waters in the summer. This is true because of a great deal of accumulated black muck in the bottom of the bay which is composed primarily of dead plant material that uses oxygen to decompose. Because of this high demand for oxygen by the muck and the size of the Bay, any such artificial aeration would demand a very large aeration system at great expense and substantial noise disturbance to residents from such equipment. The ongoing study in the Bay, known as the Clean Lakes Study, has been evaluating alternatives for reducing phosphorus within Irondequoit Bay and has addressed the costs and problems associated with aeration. It is possible that once some sort of sealing of the bottom sediments has occurred, maintenance of oxygen in lower water may require minimal aeration which can be implemented without substantial disruption to the area.

Q4. Has there been any consideration as to how much phosphorus is consumed within the bay and how much actually exits the Bay into Lake Ontario through the outlet? I think this is something that should be considered in the overall report. -- Richard Van Gemert

A4. Phosphorus is used by bay plants such as algae for growth, but some phosphorus returns to the water and bottom muds when the algae die. A fair amount of phosphorus stays in the bottom muds each year, but some re-enters the water. The amount of phosphorus entering the water from bottom sediments is being studied by the Clean Lakes project.

It has been difficult to do direct measurements of phosphorus that leaves Irondequoit Bay through the outlet because water from Lake Ontario backs into Irondequoit Bay a great deal of the time. The amount of phosphorus that exits through the outlet has been estimated by Dr. Thomas Bannister of the University of Rochester to be 44.8 kilograms per day for the period between Oct. 1980 and Sept. 1981.

Assumptions used to calculate this amount were: 1) The outflow from the bay to Lake Ontario is not significantly different from the inflow to the bay from Irondequoit Creek; 2) The concentration of phosphorus in the water leaving the Bay is equal to that near the surface approximately ½ mile south of the Bay outlet where measurements are taken. The estimate for phosphorus entering Irondequoit Bay from Irondequoit Creek during the same period was

49.5 kilograms per day. Much greater amounts of phosphorus used to enter the bay when effluent from sewage treatment plants entered the water. It is believed that much of that is contained in the bottom muds.

The water quality modeling done as part of NURP considered phosphorus from bottom muds, and phosphorus exiting the bay to estimate effects of different kinds of phosphorus controls. More estimates will be made when detailed information is received from the Clean Lakes Study.

Q5. I have seen reference to spreading of calcium on the bay bottom to prevent phosphorus contained in bottom sediments from entering the bay waters. How much phosphorus do we have to remove, and from where, in order to achieve the overall results? It seems that there is an overlap of effort to remove phosphorus. -- Richard Van Gemert

A5. The use of alum (aluminum sulphate) is being experimented with as part of the Clean Lakes Program to reduce phosphorus entering bay water from bottom muds. Liquid alum applied to water removes phosphorus in the water, drops it to the bottom, and seals off the muds to prevent phosphorus from re-entering the water. An experiment using this method was begun this past October in a portion of the Bay known as Ides Cove with good results. This method will be fully evaluated in a report to be completed this June.

The reduction of phosphorus entering the bay from the bottom muds will speed up benefits from the reduction of phosphorus entering Irondequoit Bay from Irondequoit Creek. The potential cleansing of the bay from the reduction of sewage entering the bay has been delayed and reduced by the large amount of nutrients contained in the bay bottom. By reducing this internal source of phosphorus the benefits of external phosphorus reduction efforts such as sewage and combined sewer overflow reductions and stormwater management will be accelerated. In order to keep the bay water clean the amount of phosphorus entering the bay from the Creek has to be minimal.

The water quality studies in the Irondequoit Basin have been designed to compliment each other. The NURP, Agricultural Runoff Study, and the Clean Lakes Program are all looking at different sources of pollution to Irondequoit Bay; namely, urban runoff, rural runoff, and polluted bottom muds respectively. The sources of phosphorus in urban areas are different than from agricultural sources. They also have different controls. If phosphorus from urban and rural runoff is reduced to 14 kilograms per day into Irondequoit Bay with no other action, it would likely take several years to observe a substantial water quality improvement. If alum is used to reduce phosphorus in bottom muds with no other action, a desirable water quality will be attained immediately, but it is not known for how long it will last without other reductions of incoming pollutants. Because of these limitations, an appropriate solution is to look at all sources and solutions to find a way to most efficiently improve the water quality. This will done through the Water Quality Management Plan project this year.

Q6. I am making these comments on behalf of the Ground Water Purveyors Organization. The membership of this informal organization is made up of officials representing the villages of Churchville, East Rochester, Pittsford and Webster of Monroe County.

One of the goals of the organization is to maintain accurate public awareness of the natural benefits of ground water supplies.

Monroe County is blessed with vast quantities of good quality surface and ground water. The Irondequoit Buried Valley in the NURP study area is a productive major ground water source in New York State supplying a population of 49,000 people not including homes with private well supplies. Water resource planning for the basin must be coequal and cannot regard ground water and surface water systems independently.

The draft NURP report is an excellent document that is well organized with conclusions referenced to the text material. The most disturbing portion of the report is the low priority and apparent lack of concern for the valuable ground water resource in the basin. This is illustrated on page 28 with the following quotation: "Of importance to this study, as it relates to the potential for storm water infiltration is a wide buried valley that exists throughout a portion of Irondequoit Bay watershed that is known as the Irondo-Genesee Valley". There is no further elaboration or explanation that this is a source of drinking water for thousands of people, is classified by the New York State Department of Environmental Conservation with the highest quality standard of any classified water, and that testing by the Monroe County Health Department and the Ground Water Purveyors indicates that all the standards of quality are presently being met. -- Dewayne Day

A6. It has been recognized by the NURP participants that ground and surface water systems need to be evaluated as one integrated system and not as two totally separate entities. When this NURP project began, local interests tried to have a ground water model done as part of the NURP study but the U.S. Environmental Protection Agency and the U.S. Geological Survey did not approve it. There is a current agreement with the Ithaca office of the U.S. Geological Survey to address the need for a better understanding of ground water through the review of existing information. Also, the primary focus of the Long Island NURP is groundwater impacts. Information from these projects will be used along with the information learned from the NURP, the Clean Lakes Project, and the Agricultural Runoff study to develop an overall water quality management plan. Final NURP report recommendation #7a states that one element of the upcoming comprehensive water quality management plan should be to resolve and integrate technical issues relating to established surface and ground water quality goals.

References to the use of groundwater as a drinking source occur on pages 108,131, and 138 in the "Technical Assessment" section of the draft of the final report. References are also included in the final report. The NURP study was not able to test groundwater and therefore did not report groundwater quality. Information on the classification and quality of the groundwater will be considered in the overall water quality management plan as noted above.

Q7. The report recommends that "Monroe County should require the investigation of the potential for controlling storm water runoff through groundwater discharge". This implies that storm water discharge would flow underground horizontally and at an elevation higher than the aquifer used for drinking water and there would be no vertical movement between the layered stratas. Groundwater consultants for the Purveyors disagree with that concept, and in their effort to reduce the mineral content of the existing source by drilling at shallower depths, are concerned about this proposal. -- Dewayne Day

A7. The draft of the final report does not state that Monroe County should require the investigation of the potential for controlling stormwater runoff through groundwater discharge. That statement was made in the 45-day notice of the public hearing which was written before the final printing of the draft of the final report. The report recommendations made in the draft report regarding stormwater infiltration state that: "Monroe County should proceed to investigate control measures applicable to specific urban areas, such as the use of swirl concentrators and stormwater infiltration measures since these areas were found to contribute high pollutant stormwater loads to Irondequoit Bay." As a result of public comment, the recommendation now appearing in the Final Report states that "Monroe County should investigate control measures applicable to specific high density urban areas since these areas were found to contribute high pollutant stormwater loads to Irondequoit Bay."

The other recommendation in the draft report regarding this subject states "Infiltration of stormwater into the upper soil layers should be maximized for all new developments. Infiltration can be accomplished by many accepted methods which do not inject stormwater directly into subsurface aquifers. Plans for new development, as reviewed by the governing municipal entity under the development review and approval process, should include measures for stormwater infiltration and sediment control. To provide the necessary basinwide information Monroe County should map surfical soils."

As a result of public comment this recommedation has been changed in the final report as follows: "Drainage systems which maintain the natural infiltration of stormwater into the aerated (i.e. upper) soil layer should be considered for all new developments. Such drainage measures would minimize the rate and quantity of surface runoff and, therefore, should be encouraged by all municipalities. Site development feasibility studies should include consideration of subsurface conditions to aid in implementing this recommendation. Direct injection of stormwater into a useable groundwater aquifer is not considered desirable, and therefore, is not recommended."

It should be noted that maintaining natural stormwater infiltration at levels equal to rates which existed prior to development can be as simple as providing as much open space as possible, minimizing impervious surfaces, and planting temporary ground cover.

There has been no implication that there is an impermeable separation between water penetrating surface soils and water ultimately reaching the aquifers that are deeper. A large percentage of stormwater falling on an urban or non-urban area under present conditions goes into the groundwater and recharges the aquifer. The controlled infiltration of urban stormwater runoff into the zone of aeration is not likely to have any more negative effect, and may have a positive impact by allowing the removal of more trace pollutants before the water reaches the aquifer.

As stated in the question, some groundwater consultants have suggested that the mineral content of water for municipal groundwater sources can be reduced by utilizing shallower wells. Although mineral content may be reduced, preliminary data from consultants show more serious problems with these shallower aquifers. Some portion of the deterioration of water quality from dissolved solids has been from deicing salts indicating that shallower aquifers may be more vulnerable.

Q8. During the past twenty years, millions of dollars have been spent for the abatement of pollution of the surface waters. Conversely, groundwater resources in Monroe County have been totally ignored.

Reported incidences of groundwater contamination from Caledonia, Elmira, Long Island and many parts of the country indicate a new menace. The need for additional information and new programming for groundwater is being recognized on many levels. Groundwater contamination from household toxics, pesticides and fertilizer application, oil, gasoline and hazardous chemical spills are being experienced on a more frequent basis.

With all these hazards, the risk of providing seepage or percolation ponds on fifty acre plots as a means of entry of surface runoff directly into the underground system seems to the Ground Water Purveyors an ominous threat. The risk of degrading a high standard drinking water to enhance the quality of a lower standard of surface water warrants an in-depth study.

A recommendation for a detailed study of the groundwater resources of Irondequoit Basin should be made part of this report. -- Dewayne Day

A8. A great deal of money has been spent to abate pollution to surface waters. Efforts have also been made to protect groundwater in Monroe County and the Irondo-Genesee aquifer. The Monroe County Health Department was responsible for the discontinuance of stormwater injection at depth in the vicinity of the East Rochester water supply to protect that supply. It is in light of that experience that the recommendation in this Urban Runoff Study has been against direct injection of water to any aquifer. Instead, natural infiltration of stormwater through the surface soils to allow purification is recommended. Stormwater has always been contaminated even under natural conditions and soil treatment has always helped produce our high quality groundwater.

Many groundwater pollution problems such as those mentioned in Caledonia, Elmira, and Long Island have occurred as a result of single catastrophic events which could occur in any aquifer at any time and have nothing to do with urban stormwater management. The major pollutant of concern in urban runoff in the Irondequoit Basin are nutrients that can be utilized by plants such as trees at some depth. The only major mobile chemical species in Irondequoit Basin urban stormwater is chloride from deicing salt.

The report does not recommend seepage or percolation ponds on 50 acre plots. The cost of percolation pits with the use of swirl concentrators is $955 per kilogram of phosphorus removed. Many other control technologies are much cheaper to implement, therefore, any percolation pits that might be used would not be on a widespread basis.

As mentioned in A6., recommendation #7a states that the water quality management plan should resolve and integrate technical issues relating to established surface and groundwater quality goals. Any recommendation for a detailed study of groundwater resources will be made as part of this basinwide water quality management plan that will begin this summer.

Q9. I also am making comments that will hopefully be given consideration in further studies. An article in the "Ground Water Newsletter" is pertinent to what Mr. Day was talking about. The article is entitled, "Thousands of Surface Impoundments Pose Threats." It states that, "More than ninety percent of the hundred and eighty thousand pits, ponds, and lagoons identified in a corporate cooperative federal and state program have been found to pose at least a potential threat of groundwater contamination, a study begun five years ago has found." Most of the waste impoundments have been sited with little or no regard for the protection of groundwater quality the report says. In fact, most of the ponds are in soils that permit the liquid to leak into the groundwater. The study identified eighty thousand different sites with surface impoundments. -- Frederick Sieverts

A9. The subject article refers to an EPA report on waste disposal impacts on groundwater resources. Such waste disposal is from pits, ponds, and lagoons holding wastewater from industrial and other sources. Such disposal of wastewater is not considered in this NURP report. Urban stormwater runoff is the subject of this report. New York State is working to eliminate wastewater lagoons. The County and the State Department of Environmental Conservation should be notified of any such waste lagoons or injection wells.

Q10. A further comment is that we who are involved in the industry of groundwater, serving the needs of many municipalities and industries for the last 62 years, are concerned that our priceless groundwater supply be protected in the area presently being studied. -- Frederick Sieverts

A10. There is no one involved in water quality considerations at any level in this activity that feels that intentional degradation of groundwater by waste injection or any other means is a good idea. The infiltration of moderately contaminated stormwater from urban and non-urban areas is a natural process and that process has been demonstrated through geological time to be the primary mechanism for purifying surface water as it becomes part of the groundwater system.

Q11. I'm a member of the Monroe County Conservation Council. We have achieved a very high standard of the water quality and we are very much in favor of having water quality at the highest possible level for the general public. I'm very concerned about the accuracy of this report. If you base any work upon faulty information, that work is not going to stand up and you're not going to get the kind of results that all of us as taxpayers, or as individuals want. Your report indicates that a simplified computer model was used. I believe that the entire thing is going to have to be done over again because the model hasn't been established by the EPA yet. The whole draft report is based upon the fact on page 78 of the draft report that says that the observed results, and the calculated results are very close. It appears to me that these calculations are 70-75% off. -- Wayne Harris

A11. The simplified computer model is an Environmental Protection Agency accepted model that was obtained from the USEPA Office of Research and Development in Cincinnati, Ohio.

The basinwide runoff model uses information gathered through stream sampling and rainfall measuring to predict the amounts of pollutants that occur from all the different urban areas of the watershed during certain rainfall amounts. With this knowledge, control measures could be evaluated for those areas with the greatest problems. On specific dates relating to individual storm events there are disagreements between observed and calculated phosphorus loadings up to 70%. The numbers we are interested in are annual averages which were used to draw the conclusions in the report. When dealing with nature, there are many things that cannot be predicted accurately. When working with natural data, long term trends must be the focus. For that reason, we did not base conclusions on individual storm events but focused on annual averages where natural variations are averaged out over a longer term. We have performed several analyses on the data. A correlation coefficient of 0.90 was obtained for the calculated vs. observed loads after some minor corrections to the data base. Also, the t-test revealed that both means could be the same at the 96% confidence limit. These results further confirm the applicability of this model to natural events and systems.

Q12. I agree with the previous speaker that groundwaters in this area are of prime importance, and I find nothing in this report that refers to them in any way, shape or form. -- Wayne Harris

A12. See response in A6, A7, A8, A9, A10 above.

Q13. No reference to pesticides is made in this report. Information on pesticides are important on the impact of impounded waters on the marsh. -- Wayne Harris

A13. Any capture and retention of pesticides in the wetlands would not be desirable. The Environmental Protection Agency (EPA) has tested urban runoff for pesticides in other areas and preliminary information has not shown the presence of pesticides. Specific testing for pesticides in Irondequoit Basin was not done because rainfall conditions which the EPA required for such testing did not occur during the course of this NURP study. The report to be produced by the EPA summarizing all of the NURP projects will have more information about pesticides in urban runoff.

Pesticides used today have a relatively short lifetime and are biodegradable when exposed to soil microbes and sunlight. As a result, pesticides do not often find their way to the water.

As part of the Agricultural Runoff study ongoing in the Irondequoit Basin watershed, conservation techniques to minimize runoff of nutrients and pesticides that may move with soil particles are being evaluated.

Q14. I don't find anything in your report that refers to the phosphorus loading that the bay is presently recieving from sources other than Irondequoit Bay or Irondequoit Creek. There are presently significant sources of pollution going into the bay that will be eliminated ultimately when the tunnel is completed. This is pertinent to your report, and yet isn't mentioned. I don't see how that report has validity unless those things that I have mentioned are taken into consideration. -- Wayne Harris

A14. The major phosphorus inputs to Irondequoit Bay include runoff from Irondequoit Creek, current discharges from the City of Rochester's combined sewer overflow system, direct runoff into the Bay, and the release from sediments in the bottom of the bay. Table 29 on page 96 of the draft final report shows the amount of phosphorus coming from combined sewer overflows (CSO) as 8 kilograms of phosphorus per day. The input and importance of the CSO's is also discussed on pages 21 and 23 and Table 2 of the draft report. This is also included in the final report.

The major discussion in this report regarding phosphorus controls centers around urban runoff from Irondequoit Creek because urban runoff is the focus of the study. Other studies are looking at the other sources of phosphorus to the Bay. This report recognizes that the combined sewer overflows will soon be eliminated. Sources of phosphorus in the bottom muds are being evaluated by the Clean Lakes Study. The area directly around the bay that sheds runoff directly into the Bay is a relatively small area compared to the rest of the watershed.

Q15. When you look at some of the details of the actual technical information that was gathered, I note that it wasn't really gathered on a continual basis, but was gathered during storms. It's very difficult for me to understand how chlorides, which I normally would take to mean your measurements of salt, are much higher in summer than in the winter. The wetfall data show that this is true in Perinton, and East Rochester. That doesn't make sense. There is no explanation for that. I think an explanation is warranted. Looking at the dryfall concentrations for total phosphorus, it's difficult for me to understand the concentrations at Mendon Ponds indicating .100, and in the spring .103. If it was a dryfall, how could the concentrations be heavier when you have less of a runoff? That makes no sense and there is no explanation. I think that the sampling should have been done on a continuous basis in order to have factual information on which to base these determinations.
-- Wayne Harris

A15. Water sampling in streams was done during storms because the purpose of the study was to see how much of a pollutant problem stormwater is to the system. Substantial information on pollutant loadings was gathered during non-storm periods. This allowed comparison of stormwater pollutant loads to normal flow loads.

Wetfall/dryfall measurements were summarized in tables 3, 4, 5, and 6 of Appendix A of the draft of the final report. This represents data collected at four atmospheric quality stations where particles that fall with and without rain were collected and analyzed each month. Wetfall samples represent pollutants and particulates that fell with rainfall. It should be clear that these measurements represent what is falling from the sky and not measurements taken from a stream. Dryfall represents contaminants falling from the air without rainfall. Constituents of dryfall such as dust can be carried by the wind from other areas to the samplers. We do not have a specific explanation for chlorides in the air. Comparative values have been measured in the northeastern U.S. by Pearson and Fisher, 1981 and Peters and Bonelli, 1982. Additionally, Betson, 1978 reports that the annual input from atmospheric sources was generally many times greater than the output streamflow loading depending on the type of land use and pollutant, indicating a net loss to the system. There are many uncertainties associated with atmospheric sampling programs. Extreme care must be taken in extrapolating data from these 4 sampling stations across the entire basin. The data collected was presented as qualitative indicators of the amount of pollutants that come from the air. The results indicate that atmospheric fallout is a major contribution of chemical loading to the land. No conclusions or recommendations were tied to this wetfall/dryfall data.

Q16. I think that until these major points have been addressed that any determination of substantial taxpayer expenditure should be withheld to determine what the actual facts are. The facts are lacking in this report, which is very unfortunate because this is an extremely important matter. This report lacks the validity necessary to make a determination so important in this measure. -- Wayne Harris

A16. It is felt that responses to the above questions show that facts are substantiated and that recommendations are supported.

Q17. Mr. Jonas stated in his summary of major comments that the goal of swimmability in Irondequoit Bay may not be a desirable goal. I am wondering why that is not a desirable goal. -- Patrick Malgieri

A17. It is felt by some members of the Irondequoit Basin Subcommittee that Irondequoit Bay may not be appropriate for large scale swimming such as a beach because the bottom of the bay is very mucky. Also, the results of a limited survey sent to randomly picked individuals from our mailing list show the most desired use of the bay to people was canoeing and sailing. Overall, the use of the bay for swimming was ranked second.

Q18. What would be the effect of the impoundment of the waters in the wetlands on the recreational use of Ellison Park or substantial portion of Ellison Park? -- Patrick Malgieri

A18. With the use of a passive structure to detain water, flooding in the wetlands will occur only during low to moderate stormflow. During the high flow the control structure will be inundated so that the creek will flow as if the control stucture isn't there except for holding water to maintain the 1.5 meter depth.

Q19. Would not the sediment that would form from the impoundment of the waters change the character of the wetlands, including the channel of the creek and the nature of the floor? -- Stu Carter

A19. The rate of increased transition from wet land to dry land as a result of increased sedimentation in the wetlands is being addressed. A better understanding of the impacts on the transition of this wetland to dry land resulting from the construction of any flow stabilizing device will be developed.

The construction of a large landfill in the wetlands created the area we now call the narrows, and likely had a great impact on the rate of transition of this wetland area from wet to dry. More sediment will accumulate in the wetlands in a shorter period of time with impoundment. This may require dredging at some point. An analysis of these possibilities will be done.

It is likely that the main channel of the creek near the control structure may have to be maintained from time to time.

Q20. I am puzzled by the remarks from the users of the Irondo-Genesee under ground water basin here. Mr. Day is an expert, but he says he's here only as complaint passer. I gather that the complaint has come from the towns that draw water from that underground resource. I am puzzled because the water certainly is not a pristine reservoir of glorious water. It's a resevoir that has been overdrawn and also over salted, and when this project offered to refill it with rain water, there was a solution.

The data shows that fifty years ago the water was of good quality, and that by the late 1950's, it was either overdrawn or over salted with the deicing salt or both, and became of a much higher ionic content. What the reservoir needs is both a little more rest and some more refill.

When you put in shallow wells to allow surface runoff to percolate down instead of running off into the bay, you would be doing that basin a favor, since the suspended particles that hold most of the pollution would not get through. Why then the objections to this plan? -- George Berg

A20. No response necessary.

Q21. We are talking about the pollution of the bay, and in particular the phosphorus content after the fact, so to speak, as the rivers and tributaries are running their course and discharging into the wetlands area of the bay. What efforts are being made at the source of pollution such as at the homeowner level? Also, are we doing enough as individual municipalities with paved areas and construction sites which generate sources of this phosphorus and other things. What are we doing at the basic grass roots level at the source before the phosphorus ends up in the bay? -- Jack Holzwarth

A21. It is true that there are two chances to control pollution -- at the source and after the pollutants have entered the water system. The control at the wetlands deals with the pollutants once they are in the system. What you speak of is controlling the pollutants at the source. Source control was investigated as part of this project and on a nationwide basis. Some examples are street sweeping, cleaning catchbasins and storm sewers, etc. Such source controls were not felt to be effective for the large problems because it is difficult to clean the entire surface area of the watershed prior to a rainfall. There are some source controls that were recommended, such as an erosion control ordinance, to prevent soil loss when vegetation is stripped for development. There are so many sources that it's difficult to solve the problem with source controls. Many municipalities do have controls regarding erosion and other maintenance procedures such as street sweeping.

Q22. Each of the towns has a Conservation Board, and their job is to look over each new project and try to determine how we can prevent as much pollution to the atmosphere, prevent swift runoff, and keep the runoff as clean as possible. It isn't done as we would like, but we all try, and that's part of the help that they are getting locally. -- Marion Schneider

A22. No response necessary.

Q23. Are you recommending one or two flow control structures? -- John Stone

A23. The recommendation in the final report is for the construction of one control structure to be placed in an area known as the narrows which is located halfway between Browncroft Boulevard and Empire Boulevard.

RESPONSE TO WRITTEN COMMENTS RECEIVED

Q24. I want to express my whole hearted agreement with the NURP recommendation to hold back nutrient polluted water in the Irondequoit Creek wetlands. Lets allow the cattails and sedimentation to do the work for us--its cheaper and better than we could do it. When you build the "control structure" I hope that the design will include a walkway across it. This will be invaluable to the County Recreationways trail building project for the Irondequoit Creek trail being planned from the Bay to the barge canal. We need a cross-over at that location. -- Stephen C. Weber, Co-Chairman of the Recreationways Irondequoit Creek Trail Project.

A24. Meetings with representatives of the trails group have been and will continue to be held to assure compatibility between the two projects. A walkway across the control structure would be helpful for stream gaging procedures. Both the trail and the control structure will become a part of the Ellison Park Comprehensive Plan and we will encourage simultaneous construction of both. Funds have not yet been obtained for either project.

Q25. Recommendation #4 of the draft NURP report states that erosion/runoff control ordinances based on performance standards and structured to meet local needs should be adopted by the governing municipal entities within the watershed on a town by town basis. This is a piece meal approach to a countywide problem. The Monroe County Health Department has required erosion control plans for projects which we have approved since the mid 1970's based on stream standards in Article 17 of the Environmental Conservation Law. We have been very successful in getting developers to prepare erosion control plans. Unfortunately, we have relied on staff of towns to handle the field work, and have found through spot checks that in some towns there is very good field inspection, but in most towns very little is being done in this area. I believe that a countywide erosion control ordinance should be adopted with the Monroe County Health Department responsible for implementation and enforcement. This could be approached through adoption of the ordinance into the Monroe County Sanitary Code. Our plan review workload would not increase significantly. Field inspection would be a significant new workload and would require additional staff. Some laboratory support is also necessary to evaluate the effectiveness of the erosion control mechanisms. The erosion control code could be written to allow towns wanting to adopt and enforce thier own code to have the responsibility transferred to them provided their requirements are at least as stringent as the County code. We could continue to perform the plan review function and conduct spot checks during construction to ensure control measures are effective in those towns delegated the responsibility. -- Richard Elliott, Monroe County Department of Health, member, Irondequoit Basin Subcommittee

A25. Recommendation #4 of the final NURP report is being changed to state that "An erosion/runoff control ordinance based on performance standards, structured to meet local needs, and providing for a means of enforcement should be adopted by county or local government." Decisions on the most appropriate way to enact and enforce erosion control will be made as part of the Overall Water Quality Management Plan project to start this summer. The alternative of a County ordinance will be examined as one alternative.

Q26. Recommendation #6 of the draft NURP report concerns infiltration of stormwater into the upper soil layers in new development whenever possible. On page 136 of the draft report it is stated that a permit would be required from the New York State Department of Environmental Conservation (NYSDEC) in order to discharge stormwater to groundwater. Although it is true that NYSDEC regulations are such that permits could be required, our experience has been that the state does not require these permits. Several towns on the west side of the county have installed numerous stormwater injection wells during the last 10 years. No State permits have been required. Most of these wells are direct injection into the bedrock with no treatment. We have advised the NYSDEC Avon office of these wells and have been advised that they are not interested. The Groundwater Purveyors Organization stated at the public hearing concerns about the proposal to discharge stormwater into groundwater because of the potential for contamination. They also indicated their concern for the absence of information regarding groundwater in the Irondequoit Basin Study. I share both of these concerns. The Irondequoit Basin contains the Irondo-Genesee Aquifer which was identified in the report, Atlas of Eleven Selected Aquifers in New York by the U.S. Geological Survey dated 1982, as a heavily used surficial-deposit aquifer requiring protection from contamination. The report indicates that 47,500 people are served by this aquifer with an average daily draw of 4,018 mgd. For this reason alone it is extremely important that the recommendation for stormwater injection into the groundwater be thoroughly investigated before being implemented. -- Richard Elliott

A26. The NURP report specifically rejects any recommendation regarding injection of stormwater. Your experience in State permitting for stormwater discharge to groundwater has been the case in the past. It is our understanding that the NYSDEC is considering a stronger policy regarding groundwater injection and disposal. Concerns voiced by the Groundwater Purveyors organization are answered in Answers 6, 7, and 8.

Q27. At a regular meeting of the Monroe County Conservation Council, Inc. held on February 1, 1983, a motion was made seconded and unanimously passed requesting that you and the Monroe County Legislature take no action or expend no funds as a result of the "Final Report Irondequoit Basin Study Nationwide Urban Runoff Program" by reason of the inaccuracies contained in the report, the failure in the report to adequately consider the potential damage and hazard to the groundwater, and the failure of the report to adequately consider the damage to and filling in of the very important wetlands. -- Wayne Harris, Chairman, Air and Water Pollution Committee

A27. Comments made by Mr. Harris at the public hearing regarding inaccuracies contained in the report, the failure in the report to adequately consider the potential damage and hazard to the groundwater, and the failure of the report to adequately consider the damage to and filling in of the very important wetlands are addressed in Answers 6, 7, 8, 9, 10, 11, 12 13, 14, 15, 16, and 26. This report does not propose any actions for the County Legislature's approval. No structural actions will occur as a result of the completion of the final report for this project. The information contained in the Final NURP report and in the final reports from two other projects to be completed this summer will be considered in the preparation of a Water Quality Management Plan for the Irondequoit Basin. The Water Quality Management Plan will outline specific actions to be taken to improve and maintain water quality. The preparation of the water quality management plan will begin this summer when the results of all projects are available. The Monroe County Conservation Council, and the rest of the general public will be kept informed on the Irondequoit Basin Water Quality Management Plan project when it starts and as the work progresses.

prepared by Monroe County Department of Planning
April, 1983

THOSE PRESENT AT THE JANUARY 25, 1983 NATIONWIDE URBAN RUNOFF PROGRAM PUBLIC HEARING

CITIZENS AND ORGANIZATIONAL REPRESENTATIVES

Raymond M. Avery	Citizen
Rod Bailey	Citizen
Robbie Baltzer	Allyns Creek Garden Club
Tom Bannister	University of Rochester
John Bater	Monroe County Agricultural and Stabilization Conservation Service
Gary Bennett	Citizen
George Berg	Citizen
Bob Blanchard	Citizen
Dan Bowerman	Democrat & Chronicle
Russel A. Bowman	Citizen
Larry Brunelle	Citizen
Bruce W. Butler	N.Y.S. Dept. of Environemental Conservation
Angie Cannon	Citizen
Stuart Carter	Citizen
Richard Case	Citizen
Ronald W. Centola	Citizen
Frank Crombe	Citizen
Dewayne Day	Ground Water Purveyors
Patricia DeJoy	Citizen
Charles DiPerri	Citizen
Chris Edwards	Citizen
Bruce E. Eseltine	Citizen
Gregory Fiorito	Citizen
David Fox	Citizen
Rosa Fox	Citizen
Nancy Frank	Citizen
Peter W. Frank	Citizen
Dale Frankish	Citizen
Sharon Friedlander	WXXI Radio
Don Friedler	Citizen
Eileen Gallagher	Citizen
James R. Gerace	Citizen
Wayne Harris	Monroe County Conservation Council
Louise Hibschweide	Citizen
Jack Holzwarth	Mayor, Village of Pittsford
Carolyn Isaac	Citizen
Robert C. Isaac	Citizen
Marianne Jacobs	Wolfe Publications
David R. Jensen	Citizen
Frank Keller	N.Y.S. Dept. of Environmental Conservation
Ralph L. Kendall	Citizen
Ronald Klebes	Citizen
Frank Koster	Citizen
Judy Lane	Citizen
David Lazzar	Citizen
Donna Lewyckyj	Citizen
Robert Luce	Citizen
Mr. & Mrs. Jason Lunaire	Citizens
Jim MacWhinney	Citizen
Diane M. Madak	Citizen

CITIZENS AND ORGANIZATIONAL REPRESENTATIVES

Pat Malgieri	Citizen
James Markowski	Citizen
Gary Merowsky	Citizen
John Mersmann	Citizen
Wallace Miller	Citizen
Barb Moede	Citizen
M.C.C. Geology Dept. ACT Program	
Robert Montione	Citizen
Nickolas Musseri	Citizen
James Morhouse	Citizen
Margaret Oppenheimer	Citizen
Richard E. Orioli	Times Union
George Q. Public	Citizen
Tom Quinn	Citizen
Edwin Ramos	Citizen
Adrian Rand	Citizen
Jim Robins	Citizen
Melvin W. Rought	Citizen
Ken Ruedin	Citizen
Elsa Schaefer	Citizen
Scott Schmidt	Citizen
Marion Schneider	Citizen
Ronald J. Schneider	Citizen
Bill Shearer	Village of Webster
Frederick Sieverts	Citizen
David M. Skinner	Citizen
William D. Smith	Rochester Institute of Technology
M.E. Soranno	Citizen
Larry Stid	City of Rochester
Robin Stone	Citizen
A. Sutera	Citizen
Madeleine Tourbin	Citizen
Richard Valenti	Citizen
Richard Van Gemert	Citizen
Phil Vicari	Citizen
Elmer Wagner	N.Y.S. Dept. of Environmental Conservation
C. Wallace	Citizen
Kim Walsh	Citizen
Gloria Washburn	Citizen
Richard Washburn	Citizen
Barbara Wheat	Citizen
Sid Wheat	Citizen

IRONDEQUOIT BASIN SUBCOMMITTEE
WATER QUALITY MANAGEMENT COMMITTEE

Robert Antell	Citizen
Olga Berg	League of Women Voters
Anna Bundschuh	Citizen
Rick Cortina	Town of Brighton
Lake Edwards	Town of Perinton
Richard Elliott	Monroe County Dept. of Health
Mike Flanigan	Environmental Management Council
Irene Gossin	Town of Penfield
John Hopkins	Citizen
Robert Jonas	Citizen
Krishan Mago	Town of Irondequoit
Don B. Martin	Director, Monroe County Dept. of Planning
Tom Nally	Monroe County Cooperative Extension
Betty VanHuysen	Citizen
Edward Watson	City of Rochester
Richard D. Wiles	Town of Brighton

NURP PROJECT STAFF

Jay Bloomfield	N.Y.S. Dept. of Environmental Conservation
Richard S. Burton	Monroe County Dept. of Health
David Carleo	O'Brien and Gere Engineers
Kathie DeNicola	Monroe County Dept. of Health
Robert Gallucci	Monroe County Dept. of Engineering
Donald Jones	Monroe County Dept. of Health
Bill Kappel	U.S. Geological Survey
Ann Marie LaBella	Monroe County Dept. of Health
George Landgren	Monroe County Dept. of Engineering
Patty Malgieri	Center for Governmental Research, Inc.
C.B. Murphy	O'Brien and Gere Engineers
Margy Peet	Monroe County Dept. of Planning
Scott Quinn	N.Y.S. Dept. of Environmental Conservation
Richard Rising	Monroe County Dept. of Planning
Edwin C. Tifft	O'Brien & Gere Engineers
Dick Yager	U.S. Geological Survey
Phillip J. Zarriello	U.S. Geological Survey

APPENDIX G

CONVERSION FACTORS

CONVERSION FACTORS
SI Metric to U.S. Customary

SI Metric Unit	Symbol	Multiplier	Abbr.	U.S. Customary
centimeter	cm	0.394	in	inch
cubic meter	m^3	0.000811	ac-ft	acre-foot
	m^3	35.31	ft^3	cubic foot
	m^3	0.264	gal	gallon
cubic meter per second	m^3/sec or cms	35.31	ft^3/sec	cubic feet per second
	m^3/sec or cms	22.83	Mgal/day	million gallons per day
degree Celsius	°C	1.8 x °C + 32	°F	degree Fahrenheit
hectare	ha	2.47	ac	acre
kilogram	kg	2.20	lb	pound
kilogram per hectare	kg/ha	0.89	lb/ac	pounds per acre
kilometer	km	0.62	mi	mile
liter	l	0.264	gal	gallon
meter	m	3.23	ft	foot (feet)
milligrams per liter	mg/l	1.00	ppm	parts per million
square centimeter	cm^2	0.155	in^2	square inches
square kilometer	km^2	0.386	mi^2	square mile

NOTE:

Multiples	Prefixes
1000	kilo-
0.01	centi-
0.001	milli-
0.000001	micro-